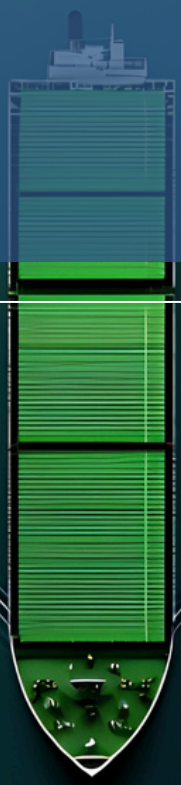
FROM COMPLIANCE TO COMPETITIVENESS

Advancing Green Shipping & Sustainable Maritime Technologies In Africa

August 2026



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Independent external readers drawn from maritime policy, port operations, energy and development finance (review process described below)

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About Innovate Maritime Africa

Innovate Maritime Africa (IMA) is positioning itself at the forefront of Africa's maritime transformation, building a future where innovation, technology and sustainability are not simply responses to industry challenges, but engines of growth and competitiveness. As Africa's maritime sector navigates increasing environmental expectations, evolving international regulations, operational inefficiencies and the urgent need for cleaner technologies, IMA is creating a platform that connects maritime expertise with entrepreneurship, research and technology. Its venture-studio model is deliberately problem-first: identifying real challenges across shipping, ports, logistics and the wider blue economy, then working with founders, industry stakeholders and partners to turn those challenges into scalable solutions.

Against this backdrop, IMA's first white paper, "FROM COMPLIANCE TO COMPETITIVENESS: Advancing Green Shipping & Sustainable Maritime Technologies in Africa," represents a timely contribution to the continent's maritime innovation conversation. The paper can serve as a call to action for African maritime stakeholders to look beyond compliance as a regulatory obligation and recognize decarbonisation, green technologies, digitalisation and sustainable operations as opportunities to strengthen competitiveness, attract investment and build globally relevant African maritime solutions. It reflects IMA's broader vision of a sustainable, digitally advanced maritime sector driven by homegrown innovation, while creating a bridge between policy, industry and entrepreneurs who can translate sustainability ambitions into practical, commercially viable technologies. In that sense, the white paper is more than a research publication, it is a statement of intent: Africa should not merely adapt to the future of green shipping; Africa should actively build and compete in it.



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Message from Innovate Maritime Africa

Africa enters the maritime energy transition with both exposure and strategic opportunity. The continent depends heavily on ports and maritime corridors – roughly four-fifths of Africa's trade by volume moves by sea yet its economies carry different combinations of high logistics costs, constrained public finance, infrastructure gaps, energy limitations, uneven digital capacity and skills shortages.

At the same time, Africa possesses major trade routes, some of the world's best renewable-energy resources, strategic industrial locations, a substantial maritime labour force, universities and fast-integrating regional markets that can support a more competitive and lower-carbon maritime future. The question is not whether Africa will be affected by the transition, but whether it will shape the terms on which it participates.

Innovate Maritime Africa takes a clear position. Africa should not remain a passive recipient of standards, technologies and investment models designed elsewhere. The transition must be African-led, differentiated and grounded in evidence. Operational efficiency and digital readiness should advance alongside vessel, fuel and energy transition. Safety and lifecycle integrity must come before scale. Financing must follow credible demand, governance and repayment logic. Skills, local capability and social inclusion must be treated as core infrastructure, not secondary benefits.

This white paper is offered as a platform for coordinated action. Innovate Maritime Africa will contribute through evidence synthesis, policy convening, readiness tools, knowledge partnerships and the preparation of practical project concepts. Its ambition is to help African governments, ports, industry, financiers, universities and communities move from fragmented initiatives to credible pathways that protect trade competitiveness and expand Africa's role in emerging green maritime value chains.

Mr. Tobi Alade
Project Director, Innovate Maritime Africa



Acronyms and Abbreviations

AfCFTA	African Continental Free Trade Area
AfDB	African Development Bank
AIM	Africa's Integrated Maritime (Strategy)
AU	African Union
CII	Carbon Intensity Indicator
DCS	IMO Data Collection System
DFI	development-finance institution
EEXI	Energy Efficiency Existing Ship Index
ETS	Emissions Trading System
EU	European Union
FAL	Convention on Facilitation of International Maritime Traffic
GFI	GHG Fuel Intensity
GHG	greenhouse gas
IMO	International Maritime Organization
IRENA	International Renewable Energy Agency
JIT	just-in-time
LCA	life-cycle assessment
LSCI	Liner Shipping Connectivity Index
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Marine Environment Protection Committee
MEL	monitoring, evaluation and learning
MSW	maritime single window
NAP	national action plan
NZF	IMO Net-Zero Framework
PCS	port community system
PPP	public-private partnership
REC	regional economic community
SEEMP	Ship Energy Efficiency Management Plan
WtW	well-to-wake
ZNZ	zero- or near-zero (GHG)

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Executive Summary

The maritime energy transition is changing the economics of shipping. Climate regulation now interacts with fuel choice, vessel deployment, port selection, cargo-owner procurement, insurance, finance, emissions reporting and supply-chain strategy. The 2023 IMO GHG Strategy set an ambition for international shipping to reach net-zero greenhouse-gas emissions by or around 2050, with indicative checkpoints for 2030 and 2040 and a target for zero- or near-zero fuels and technologies to reach at least 5%, striving for 10%, of the energy used by international shipping by 2030.

The regulatory pathway is still being negotiated, and its trajectory matters more than any single date. At its eighty-third session (7–11 April 2025), the IMO Marine Environment Protection Committee approved, in principle, draft amendments to MARPOL Annex VI known as the IMO Net-Zero Framework, combining a lifecycle-based global marine fuel standard with an emissions-pricing mechanism linked to an IMO Net-Zero Fund.

Formal adoption was expected at an extraordinary session in October 2025, but the Committee voted to adjourn adoption for one year. At MEPC 84 (27 April–1 May 2026) member states could not bridge the gap between those seeking adoption with minimal change and those favouring a market-readiness approach; technical work on the implementing guidelines continued through the intersessional working group ahead of MEPC 85 (November 2026), with the adjourned extraordinary session due to reconvene in the autumn of 2026. If adopted, the amendments would proceed under MARPOL's tacit-acceptance procedure, with entry into force expected around spring 2028. The direction of travel is therefore clear, but the final thresholds, revenue arrangements and entry-into-force date remain unsettled as at publication.

Regional measures, by contrast, are already applicable. FuelEU Maritime has applied since 1 January 2025 to covered ships above 5,000 gross tonnage calling at European ports, progressively tightening the permitted well-to-wake greenhouse-gas intensity of onboard energy from a 2% reduction in 2025 toward 80% by 2050 against a 2020 reference.The EU Emissions Trading System has covered maritime carbon-dioxide emissions since 2024, with surrender obligations phasing in at 40% of 2024 emissions, 70% of 2025 emissions and 100% from 2026 emissions, and with methane and nitrous oxide entering scope from 2026.

For African economies these measures do not create one uniform impact. Exposure varies according to trade routes, cargo type, contractual arrangements, fleet composition, port efficiency, access to alternative fuels and the ability of firms to pass costs through supply chains. Yet the direction is clear: carbon performance and emissions transparency are becoming part of the commercial environment in which ports, shipping services and export corridors compete. UNCTAD has warned that environmental-compliance costs, port disruption and freight-rate volatility are reshaping maritime transport economics, especially for economies already exposed to high logistics costs and external shocks.

Africa should respond neither by delaying action nor by copying fuel-centred investment models developed for ports with different grids, capital markets, industrial systems and vessel demand. The appropriate strategy is differentiated, technology-neutral, readiness-led and economically grounded. It begins with measures that reduce avoidable emissions and trade costs now – reliable operational data, vessel-arrival coordination, efficient cargo clearance, digital interoperability, energy management, maintenance, safety systems, skills and project preparation – while advancing vessel, port-energy and fuel transitions in the locations and market segments where demand, lifecycle performance, infrastructure and finance can be demonstrated.

Operational efficiency is not a substitute for decarbonising propulsion and marine energy. Most international-shipping emissions arise from vessel energy use, and long-term alignment with net-zero objectives will require efficiency technologies, renewable electricity, low- and zero-GHG fuels and changes in vessel design and operation. The efficiency agenda matters because it reduces waste, improves schedule reliability, creates the data needed for investment and lowers the risk that expensive assets are deployed into poorly governed systems. It is a foundation and accelerator, not the entire transition.

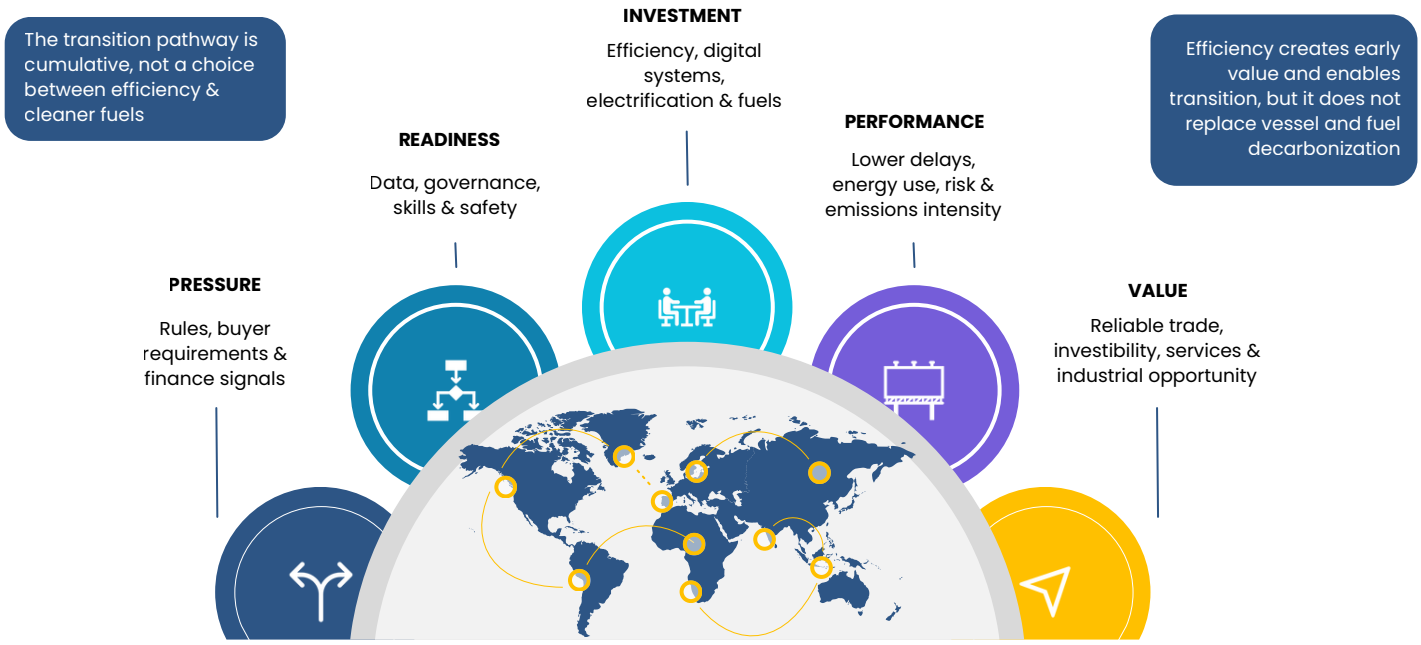


Figure 1. From regulatory exposure to maritime competitiveness

African maritime policy must distinguish between major gateway and trans-shipment ports, resource-export corridors, island and short-sea systems, inland-water networks, smaller emerging ports, renewable-energy coastal clusters, landlocked corridor economies and repair, training or service hubs. These categories can overlap, but they require different investment sequences. The typology is a decision tool, not a ranking of countries or ports.

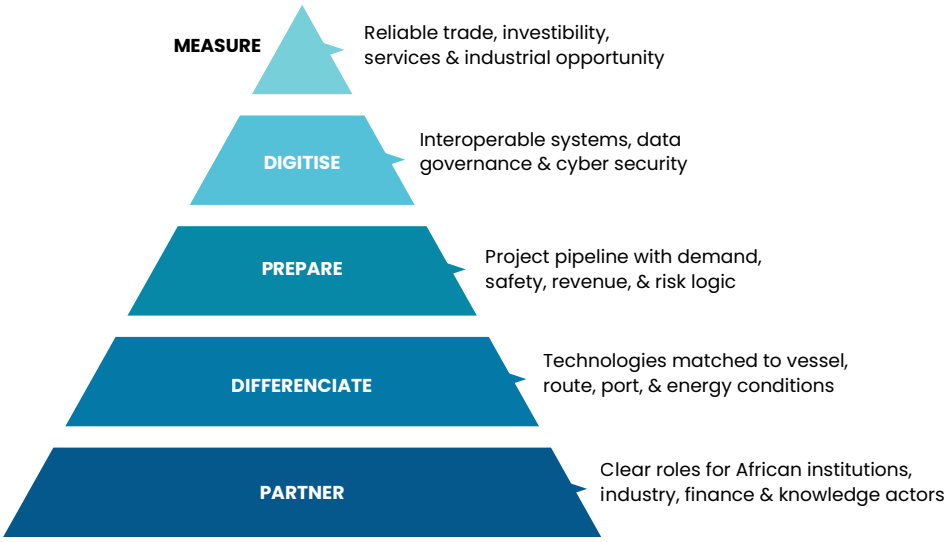
Five priorities

Five priorities emerge from the analysis. First, African governments and ports should establish credible emissions and operational baselines, because projects cannot be prioritised, financed or verified without reliable data. Second, digitalisation should be treated as institutional infrastructure: maritime single windows have been mandatory under the IMO Facilitation Convention since 1 January 2024, while port community systems, standardised port-call data and cargo-visibility tools require governance, cybersecurity and process redesign, not software procurement alone.

Third, technology selection should occur by vessel segment and port context, using lifecycle emissions, safety, commercial maturity, infrastructure, maintenance and demand as decision criteria. Fourth, governments and project sponsors should create finance-ready pipelines with defined owners, revenue or savings, procurement routes, risk allocation and measurable climate outcomes. Fifth, the transition should be governed as a partnership between public authorities, ports, carriers, cargo owners, energy suppliers, financiers, technology providers, research institutions, training bodies, labour organisations and communities.

Five Priority Actions

A practical agenda for the first pase of implementation



The financing requirement is not solved by naming green bonds, blended finance or public-private partnerships. Each asset needs a financing architecture. Baseline studies and capacity building may require grants or public budgets. Digital platforms may be financed through public investment, operator capital or service arrangements, depending on governance and revenue. Port-equipment electrification can draw on operator capital, green loans, leasing or vendor finance when lifecycle savings are credible. Electric ferries need predictable demand, charging infrastructure, affordable tariffs and a battery-replacement strategy. Shore power requires sufficient vessel calls, grid capacity, technical standards and an agreed tariff. Alternative-fuel infrastructure requires long-term offtake, credible fuel supply, safety systems and counterparties able to carry demand and price risk. Foreign-exchange exposure deserves particular attention where debt is denominated in hard currency but project revenues are local.

Partnership is an implementation mechanism, not a communications category. Policy partners align mandates and regulation. Ports, shipping lines, cargo owners and utilities define demand and operating conditions. Knowledge partners produce evidence and train people. Classification, safety and emergency-response institutions establish technical confidence. Development-finance institutions and climate funds can support project preparation, concessional capital and risk mitigation. Communities, workers, women's and youth organisations ensure that affordability, employment quality, safety and local benefits are addressed. The implementation pathway runs from 2026 to 2035, with a longer perspective to 2050. The first phase establishes evidence, governance and quick operational gains. The second prepares projects and pilots. The third mobilises finance and implements selected assets. The fourth independently evaluates results and scales only what demonstrates operational, financial, environmental and safety value. The fifth integrates successful corridors and industrial value chains. Decision gates prevent political visibility from outrunning technical readiness.

The intended outcome is not a continent covered with identical "green port" projects. It is a portfolio of African maritime systems that can demonstrate reliable logistics, credible emissions data, safe technology adoption, stronger human capability and investment propositions grounded in local demand. That portfolio can reduce the risk that decarbonisation compounds existing trade disadvantages, while creating selective opportunities in port services, digital systems, renewable energy, vessel conversion, maintenance, fuel certification, training and regional corridor development.

Methodology and limitations

This white paper draws on a structured review of international maritime regulation, African continental policy frameworks, official port and government publications, multilateral reports, technical studies and selected project documentation published principally between 2016 and 12 July 2026. Regulatory facts were verified against primary sources, including IMO resolutions and meeting outcomes, European Commission directorates, UNCTAD and African Union instruments. Older sources were retained where they remain foundational or legally relevant, notably the 2050 Africa's Integrated Maritime Strategy and Agenda 2063. Case studies were selected for relevance to different maritime-system types, availability of traceable evidence and clarity of implementation lessons.

The report does not constitute a continent-wide empirical inventory and does not rank individual ports. Publicly available information is uneven across countries and projects. Several case sources are institutional self-reports; these are identified and interpreted as evidence of stated policy or implementation rather than independent impact evaluation. Cost figures are not generalised across assets because capital requirements depend on local engineering, demand, grid, procurement, financing and regulatory conditions. Any project derived from this paper requires country-specific feasibility, environmental and social assessment, safety analysis and legal review.





STRATEGIC PROPOSITION

From Compliance to Competitiveness: The Case for Action

1

Africa's interest in green shipping is often framed as a future compliance question: how states and firms will respond when international rules require lower-emission fuels or price greenhouse-gas intensity. That framing is too narrow. Compliance matters, but its economic effects are transmitted through freight markets, port calls, vessel scheduling, cargo-owner procurement, trade finance, insurance, energy supply and investment decisions. A port does not become competitive merely because it has announced a green strategy, and an exporter does not become uncompetitive merely because a regulation exists. Competitiveness changes when regulation interacts with the quality, cost and reliability of the logistics system.



For many African economies this interaction begins from a difficult baseline, and the numbers are stark. Logistics costs are estimated to absorb roughly 25 to 30% of trade value in Africa, against 8 to 10% in OECD economies and 12 to 14% in Asia. Intra-African trade remains close to 15% of the continent's total commerce, so more than 80% of Africa's trade is with the rest of the world and moves predominantly by sea. Any measure that raises the delivered cost of seaborne trade therefore lands on economies that are already paying a high logistics premium.

Continental frameworks name these constraints directly. Agenda 2063 identifies ageing fleets, high freight costs, poor inland transport, inadequate connectivity and port inefficiency as brakes on maritime transport and intra-African trade. The 2050 Africa's Integrated Maritime Strategy links wealth creation to secure, environmentally sustainable and better-coordinated maritime systems. These frameworks establish an important principle: decarbonisation should be designed as part of Africa's development and integration agenda, not treated as a separate environmental programme imported into the transport sector. The African Continental Free Trade Area sharpens the stakes further, since UNCTAD estimates it could raise intra-African trade by around a third if the supporting logistics are in place, and UNECA projects a 28% rise in intra-African freight demand by 2030.

The competitiveness proposition

The competitiveness proposition has four dimensions. The first is cost: fuel, carbon charges, vessel time, terminal handling, inventory and inland transport all enter the delivered cost of trade. The second is reliability: a ship or cargo owner may accept a nominally higher price where schedule integrity, data quality and turnaround are superior. The third is market credibility: verified emissions information and recognised safeguards increasingly matter to financiers, insurers and buyers. The fourth is strategic capability: the ability to develop, operate, maintain and regulate new technologies without permanent dependence on external providers.



A credible African response therefore begins by identifying which costs are avoidable, which investments are necessary, and which opportunities are conditional. Vessel waiting, truck queues, equipment idling, repeated documentation, weak maintenance and unreliable cargo evacuation impose costs that can often be reduced without committing to a particular future fuel. At the same time, the long-term transition requires

changes to ships, fuels, power systems, bunkering, standards and skills. The policy task is to sequence these elements so that early operational gains reduce exposure and create a platform for later investment.

A readiness-led, technology-neutral thesis

This paper proposes a readiness-led and technology-neutral pathway. "Readiness" means the verified ability to measure emissions and performance, coordinate public and private actors, enforce safety, operate and maintain assets, prepare investments, and make decisions based on route and vessel evidence. "Technology-neutral" does not mean indifferent to technology. It means that governments should establish performance, safety, lifecycle and development criteria before selecting a technology, rather than allowing a fuel announcement or vendor proposal to determine policy.

The approach rejects two extremes. The first is passive compliance, in which African actors wait for external regulation and absorb the resulting costs without developing domestic capability. The second is premature infrastructure, in which highly visible fuel or port projects proceed before demand, energy, safety and financing conditions are established. Between them lies a structured pathway: no-regret operational foundations; segment-specific vessel and port technologies; fuel and energy readiness; corridor partnerships; and selective industrial positioning. Chapter 5 develops this pathway in full; the remainder of the paper should be read as its elaboration.

Central proposition

Africa should reduce avoidable emissions and trade costs immediately, while developing vessel, port-energy and fuel pathways only where lifecycle performance, demand, safety, local capability and finance can be demonstrated. The objective is not the appearance of green infrastructure. It is durable maritime competitiveness under tightening carbon constraints.



REGULATORY AND COMMERCIAL CONTEXT

Global Maritime Decarbonization and the Emerging Competitiveness Regime

2



The global regime is composed of measures at different legal stages. Some are already mandatory under MARPOL Annex VI. Others apply within regional jurisdictions. The IMO Net-Zero Framework remains a draft amendment awaiting formal adoption. Voluntary corridors, cargo-owner commitments and financial-disclosure practices create additional market pressure but should not be confused with legal obligations. Reading these instruments together, rather than in isolation, is what allows an African actor to distinguish a binding requirement from a commercial signal.

The IMO pathway

The 2023 IMO GHG Strategy raised the level of ambition for international shipping. It calls for carbon intensity to decline by at least 40% by 2030 compared with 2008; for zero- or near-zero-GHG technologies, fuels and energy sources to represent at least 5%, striving for 10%, of the energy used by international shipping by 2030; and for total annual GHG emissions to fall by at least 20%, striving for 30%, by 2030 and at least 70%, striving for 80%, by 2040, against 2008. Net-zero emissions are to be reached by or around 2050, taking national circumstances into account.

Short-term measures are already operational. Since 1 January 2023, ships within scope have been required to calculate their Energy Efficiency Existing Ship Index and report annual operational carbon intensity under the Carbon Intensity Indicator rating system. The enhanced Ship Energy Efficiency Management Plan connects management, fuel-consumption reporting and operational carbon-intensity planning. The IMO Data Collection System, adopted in 2016, provides annual aggregated fuel-use reporting for ships of 5,000 gross tonnage and above and underpins operational carbon-intensity reporting.

Lifecycle accounting is central to the next phase. The 2024 IMO LCA Guidelines cover greenhouse-gas intensity across feedstock extraction or cultivation, fuel production, transport, bunkering and use on board, including electricity as an energy carrier. This matters for Africa because a fuel marketed as "green" may perform very differently depending on electricity source, methane leakage, feedstock governance, land use,

water demand or carbon origin. Well-to-wake accounting is therefore the analytical spine of any credible fuel decision.

The draft IMO Net-Zero Framework

MEPC 83 approved the draft legal text in April 2025, containing two linked elements: a global marine fuel standard based on lifecycle GHG intensity, expressed through a GHG Fuel Intensity metric, and an emissions-pricing mechanism associated with an IMO Net-Zero Fund. Approval allowed the text to proceed toward adoption; it did not make the framework legally effective. The extraordinary session convened for adoption in October 2025 was adjourned by majority vote for one year. MEPC 84, held 27 April to 1 May 2026 and the first ordinary session after the adjournment, continued discussion without resolving the central disagreements over the fund and the design of the fuel standard; a compromise between those seeking adoption with minimal change and those favouring a market-readiness approach was not reached. Guideline development continued through the intersessional working group toward MEPC 85 in November 2026, and the adjourned extraordinary session is due to reconvene in the autumn of 2026.

This distinction matters for investment. Under the MARPOL tacit-acceptance procedure, an adopted amendment is deemed accepted after a defined period and would then enter into force – currently expected around spring 2028 if adoption proceeds. Until adoption occurs, African policy should concentrate on measures that remain valuable under multiple regulatory outcomes: data capability, fuel-lifecycle literacy, safety, efficient operations, project preparation and active participation in IMO negotiations. Investment decisions should read the direction of travel without assuming that the final thresholds, revenue distribution or entry-into-force date are settled.

European measures and African exposure

FuelEU Maritime applies to covered commercial ships above 5,000 gross tonnage calling at European ports, regardless of flag, subject to specified exclusions. It measures the annual average well-to-wake GHG intensity of onboard energy, including carbon dioxide, methane and nitrous oxide, against a 2020 reference. The required reduction begins at 2% in 2025 and rises to 80% by 2050, tightening in five-year steps.

The EU ETS covers 100% of emissions from voyages between EU ports and emissions at berth in EU ports, and 50% of emissions from voyages between an EU and a non-EU port. Shipping companies surrender allowances for 40% of covered 2024 emissions, 70% of 2025 emissions and 100% of 2026 emissions; methane and nitrous oxide enter the maritime scope from 2026.

These rules can influence Africa–Europe trades, but effects will differ. The liable shipping company may pass costs to cargo interests through freight or surcharges, absorb part of the cost, alter vessel deployment, pool compliance performance or use alternative fuels. Ports can affect some operational emissions and voyage reliability but do not control vessel fuel procurement or contractual cost allocation. The correct policy response is therefore to map exposure by route, commodity and contract, rather than to publish a single estimate for "Africa".

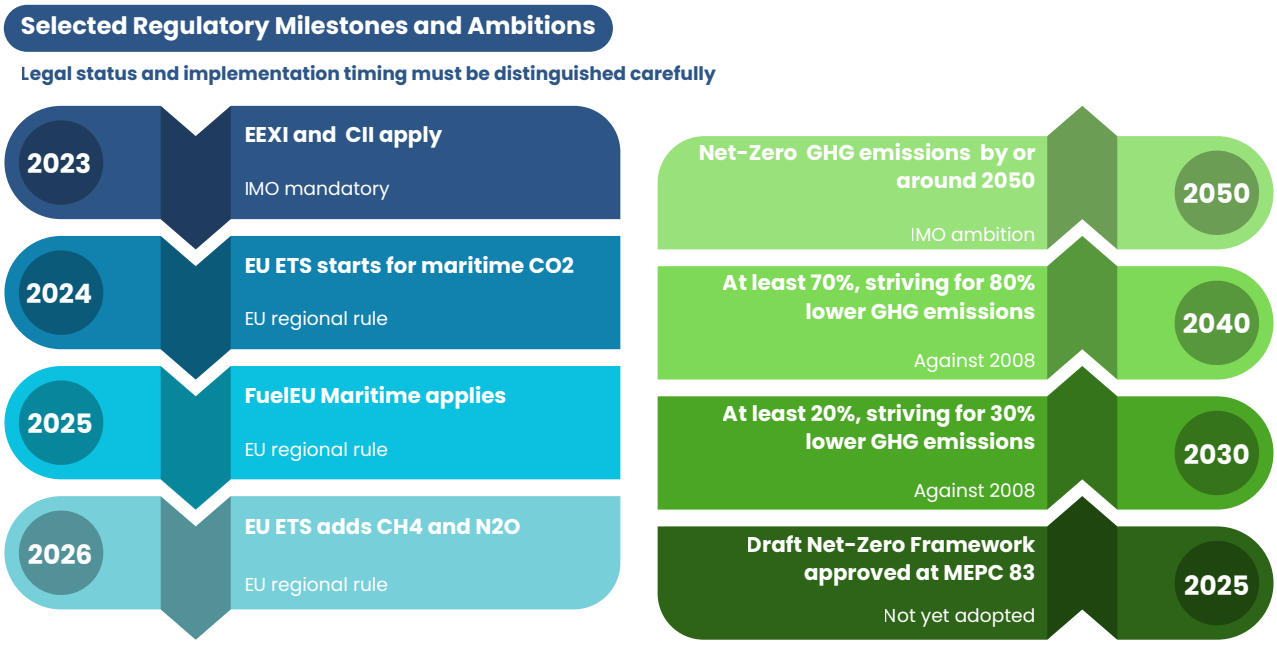


Figure 2. Selected regulatory milestones and ambition points, 2023 to 2050

Source: Authors' visual based on the IMO 2023 GHG Strategy, MARPOL Annex VI measures, FuelEU Maritime and the EU ETS. The IMO Net-Zero Framework remains a draft instrument and its timetable is subject to future IMO decisions.

Table 1. Regulatory and market instruments

Instrument	Status at 12 July 2026	Principal relevance for African actors
EEXI, CII and SEEMP	Mandatory under MARPOL Annex VI for ships within scope.	Affects vessels, operators, administrations and port-side support for efficient calls.
IMO Data Collection System	Mandatory fuel-consumption reporting for ships of 5,000 GT and above.	Requires administrative capacity and creates a basis for carbon-intensity policy.
IMO LCA Guidelines	Adopted technical guidelines (MEPC.391(81)).	Support credible comparison and certification of marine fuels and electricity.
IMO Net-Zero Framework	Draft amendments approved in April 2025; adoption adjourned; MEPC 84 (May 2026) reached no compromise; extraordinary session to reconvene autumn 2026.	Signals future fuel-intensity and pricing direction; final terms and entry into force (expected ~2028) remain uncertain.
FuelEU Maritime	Applicable since 1 January 2025.	Directly affects covered ships calling at EU ports and may alter Africa–Europe transport economics.
EU ETS (maritime)	Applicable since 2024; 100% surrender from 2026 emissions; CH_4/N_2O from 2026.	Creates allowance costs for covered voyages and strengthens emissions-data requirements.
Cargo-owner, finance and corridor initiatives	Contractual or voluntary, varying by participant.	Can influence procurement, investment and route partnerships without being universal law.



DIFFERENTIATED STARTING POINTS

Africa's Maritime, Trade, Energy and Institutional Reality

3

Africa does not have one green-shipping baseline. Its maritime systems range from large trans-shipment hubs and bulk-export corridors to island ferry networks, lake transport, small coastal ports and landlocked trade corridors. Differences in grid reliability, renewable resources, fleet ownership, port governance, finance, safety capacity, route density and industrial structure determine which interventions are feasible and when.

Recent data underline both the constraint and the momentum. UNCTAD's Liner Shipping Connectivity Index recorded Africa as the fastest-improving region between June 2024 and June 2025, rising about 10%, helped in part by the rerouting of trade away from the Red Sea. National gains were significant where investment landed: Cameroon's connectivity rose 54%, driven by the port of Kribi and a step-change in the maximum vessel size it can receive, while Mauritania and Namibia each improved by 43%. Connectivity gains of this kind are precisely what a well-targeted readiness agenda is meant to consolidate rather than leave to chance.

The continental policy architecture treats these systems as connected. The Africa Blue Economy Strategy treats shipping, transport, trade, ports, maritime safety, energy, innovative industries, governance and finance as components of a single sustainable blue economy. Agenda 2063 places ports, marine transport and energy within a broader project of integration and industrial transformation. The African Union's climate strategy adds the requirement that low-carbon development remain resilient and aligned with social and economic priorities.

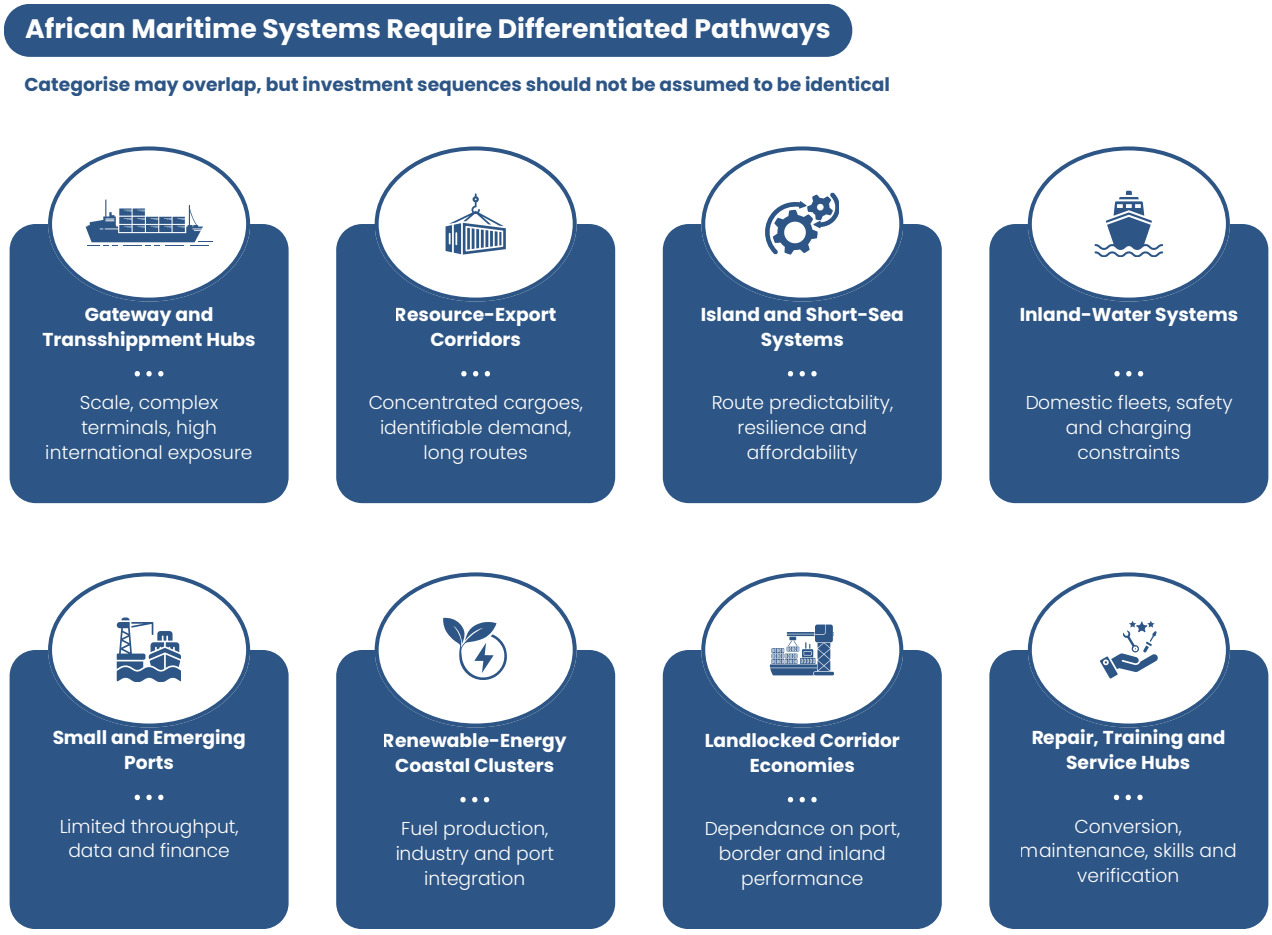


Figure 3. A typology of African maritime systems

Source: Authors' framework

Cross-cutting constraints

Several constraints recur across the typology. The first is cost of capital. Long-tenor infrastructure finance is often denominated in foreign currency, while port charges, ferry fares or domestic revenues are partly local, creating mismatch and affordability risk. The second is energy: shore power, charging and electrofuel production depend on grid capacity, renewable additionality, reliability and competing national demand. The third is institutional fragmentation: transport, ports, energy, finance, trade, customs, environment, labour and local government may hold overlapping or incomplete mandates.

The fourth constraint is fleet structure. Many African states do not control the deep-sea vessels serving their trade; international shipowners make propulsion and fuel decisions, and globally only about 8% of the fleet can currently run on alternative fuels. Public policy therefore has greater direct leverage over ports, domestic fleets, ferries, harbour craft and public procurement than over the global fleet. The fifth is human capability: alternative fuels, high-voltage systems, data platforms and lifecycle accounting require regulators, inspectors, operators, technicians, emergency responders and trainers. The sixth is evidence: public port emissions inventories and asset-level feasibility studies remain uneven.

These constraints do not justify inaction. They change the sequence. A small port with weak power supply should not be judged against a large European fuel hub. An island route should not wait for deep-sea ammonia before testing an electric or hybrid service. A bulk corridor should not procure fuel infrastructure before cargo owners, shipowners and producers agree how demand and risk will be shared. Differentiation is a discipline for ambition, not a reason to lower it.

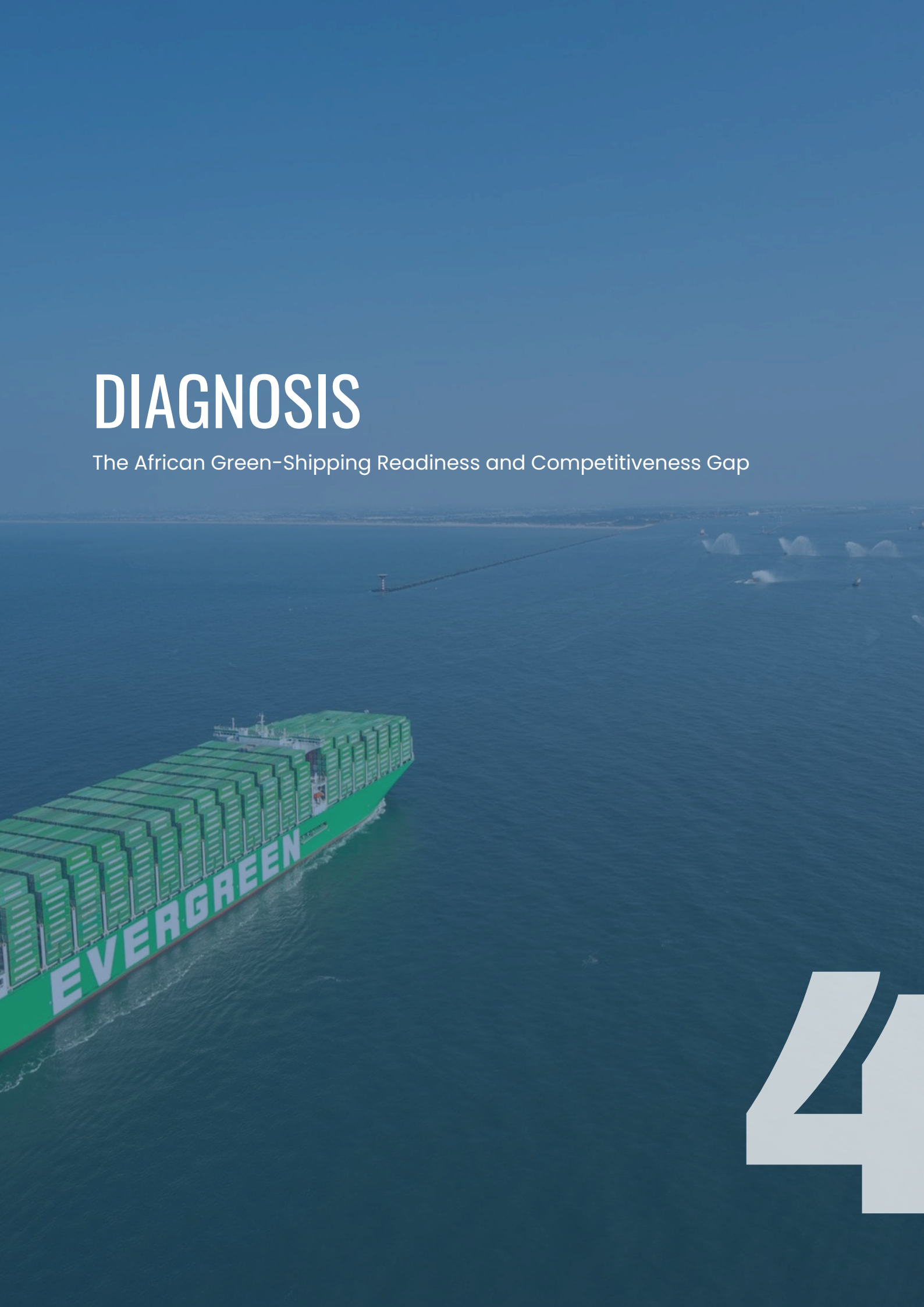


African agency

African policy should also avoid a purely reactive narrative. Governments and ports are already developing green-port policies, national action plans, renewable-energy initiatives, digital reforms and corridor concepts. The critical issue is whether these activities are connected, evidenced and scaled. Continental and regional institutions can support common guidance, knowledge exchange and representation in global rule-making. National governments determine enabling policy. Ports and operators provide data and sites. Universities and training institutions develop capability. Private investors and development partners help convert mature projects into finance.

DIAGNOSIS

The African Green-Shipping Readiness and Competitiveness Gap



4

The central policy gap lies between the speed of external change and the capacity of maritime systems to respond. It is not simply a shortage of alternative fuel. It is a multi-dimensional gap in measurement, operations, institutions, energy, safety, skills and investment delivery. Naming the gap precisely is the first step toward closing it, because each dimension has a different owner and a different remedy.

Operational and corridor readiness

Efficient port calls reduce unnecessary vessel waiting, speed recovery and fuel use. Just-in-time arrival requires reliable information on berth, fairway, nautical and terminal availability, together with contractual and operational cooperation. Pre-clearance, standardised port-call data and efficient nautical services can reduce avoidable delay, but their value depends on adoption across the port-call chain.

Cargo dwell, truck queues, yard congestion and weak inland evacuation create additional emissions and trade costs. These are not all controlled by port authorities. Customs, terminals, shipping agents, cargo owners, rail and road agencies, freight forwarders and border systems contribute to performance. A green-port programme that ignores cargo flow may improve the port's own energy use while leaving the larger logistics problem unchanged which, given Africa's logistics-cost premium, is where much of the avoidable cost actually sits.

Digital and data readiness

Since 1 January 2024, the IMO Facilitation Convention has required public authorities to establish and use maritime single windows for information on the arrival, stay and departure of ships. Compliance with the single-window requirement is distinct from having a full port community system. The latter may connect shipping, terminals, customs, logistics providers, banks and cargo owners. Both require data governance, interoperability, cybersecurity, legal recognition of electronic information and redesigned procedures.





The mandate has outrun implementation. An IMO Facilitation Committee survey found that 40% of respondents were unaware of the single-window obligation, and paper or mixed submissions still featured in nearly two-thirds of reported port calls. This gap between rule and reality is exactly the paper's thesis in miniature: the regulatory signal is clear, but competitiveness turns on whether institutions actually change how they operate.

Emissions data create a second layer. A port inventory should define boundaries, sources, methods, base year and data ownership. It should distinguish port-authority emissions from terminal, ship, truck, rail, tenant and electricity emissions. Without that distinction, a port may claim reductions it does not control or overlook sources where collaboration is essential.

Energy, technology and safety readiness

Electrification and alternative fuels introduce infrastructure and safety requirements that vary by technology. High-voltage shore connections need grid, standards, vessel compatibility and emergency procedures. Batteries require thermal-runaway controls, charging protocols, trained responders and end-of-life management. Methanol is toxic and flammable; ammonia is highly toxic; hydrogen requires careful management of leakage, ignition and storage. The correct question is not whether a technology is "green", but whether a specific port and vessel segment can operate it safely and deliver lifecycle reductions.

Finance and institutional readiness

A project pipeline is more than a list of ambitions. It requires a sponsor, defined users, demand, technical design, permits, safeguards, capital and operating cost, procurement, revenue or savings, risk allocation and monitoring. Development-finance institutions can provide preparation support, concessional finance and guarantees, but they cannot replace an accountable project owner. Blended finance is useful when public or concessional capital addresses a clearly identified risk and

mobilises additional investment; it is not a justification for poorly prepared projects.

Table 2. The readiness gap and its competitiveness effects

Readiness dimension	Typical weakness	Competitiveness effect	Minimum response
Operations	Waiting, dwell, queues, poor maintenance and weak evacuation.	Higher time, fuel, inventory and service costs.	Baseline performance, process reform and accountable operations plan.
Data and digital	Fragmented systems, duplicate submissions and unclear data ownership.	Poor visibility, slow clearance, weak verification and cyber risk.	MSW compliance, governance, interoperability and emissions-data architecture.
Energy	Unreliable grid, limited capacity or uncertain renewable supply.	Low utilisation, high tariffs and weak lifecycle performance.	Load study, grid plan, renewable assessment and demand forecast.
Safety and skills	Limited alternative-fuel, battery, inspection and emergency capability.	Operational risk, delayed approvals and weak insurer confidence.	Gap assessment, standards, competency framework, drills and maintenance plan.
Finance	No sponsor, revenue logic, feasibility or risk allocation.	Projects remain grant-dependent or fail to reach investment decision.	Preparation facility, asset-level business case and financing strategy.
Institutions	Siloed mandates and inconsistent policy.	Duplicated projects, delays and weak accountability.	Adaptable coordination mechanism linked to existing authorities.

Decision rule: a six-question readiness test

A green maritime investment should not progress to procurement until six questions have credible answers. Who owns and operates it? Who will use it? What lifecycle emissions and operational benefit will it deliver? What safety and skills system is required? How will capital and operating costs be paid? Which institution is accountable for performance?



STRATEGY

A Differentiated Transition Framework for African Maritime Systems

5

The transition should proceed through four reinforcing layers. The layers are not a universal timetable. A capable gateway may advance several simultaneously, while a smaller port may concentrate on the first. The purpose is to ensure that highly capital-intensive decisions rest on evidence and capability rather than announcement. This chapter is the operational core of the paper; the earlier chapters establish why it is needed, and the later chapters translate it into technology, finance, partnership and delivery.

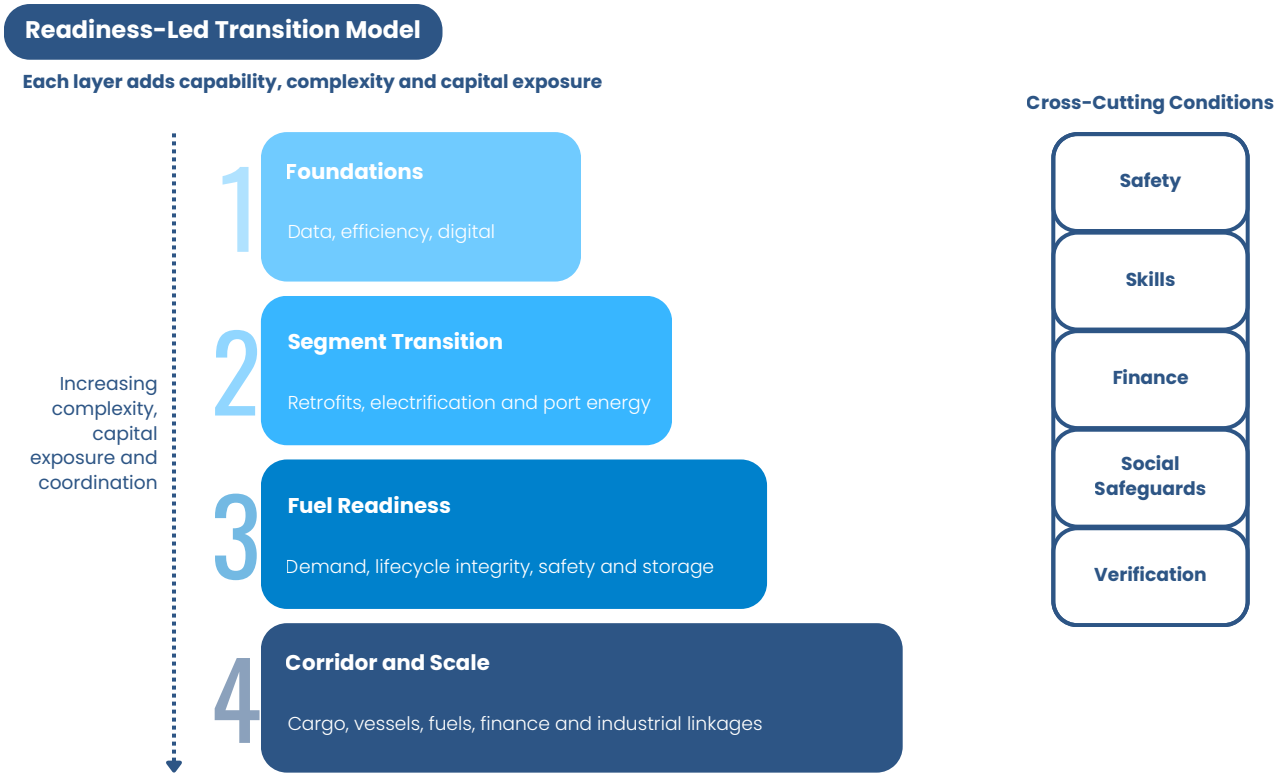


Figure 4. Readiness-led transition model
Source: Authors' framework.

Layer 1: No-regret operational and institutional foundations

The first layer includes performance baselines, emissions inventories, energy audits, digital interoperability, just-in-time port calls, maintenance, safety management, training-needs assessment and project preparation. These measures are "no regret" because they improve governance and operations under multiple fuel and regulatory futures. They also generate the evidence the next layer requires.

Layer 2: Segment-specific vessel and port transitions

The second layer selects technologies for defined vessel and asset classes. Examples include electric or hybrid ferries on predictable routes, battery-supported harbour craft, electric cargo-handling equipment, renewable power for buildings and terminal loads, hull and propulsion retrofits, wind assistance, speed and voyage optimisation, and shore-power projects with sufficient compatible calls. Segment-specific analysis prevents a technology that works on a ferry route from being treated as a solution for deep-sea bulk shipping.

Layer 3: Alternative-fuel and energy readiness

The third layer tests fuels and energy carriers against lifecycle emissions, demand, storage, safety, standards, utilities, water, land and cost. Biofuels require robust feedstock and certification. Methanol can use existing liquid-fuel handling concepts but still needs toxicity controls and credible low-GHG supply. Hydrogen may matter more as an industrial feedstock for derivatives than as a direct fuel in some locations. Ammonia may serve deep-sea segments but requires stringent toxicity and emergency arrangements. LNG may reduce some

air pollutants and, in certain configurations, tank-to-wake carbon dioxide, but methane slip and asset-lock-in risks limit its credibility as a long-term net-zero strategy.

Layer 4: Corridor and industrial scale

The final layer brings together cargo, vessel, port, energy and finance. A green corridor requires predictable trade, participating cargo owners, vessel deployment, fuel supply, compatible ports, regulation and risk sharing. Industrial opportunity may include renewable power, fuel production, bunkering, ship repair, conversion, certification, data services, training and local suppliers. These benefits are conditional. Export-oriented fuel production should be evaluated against domestic power access, water, land, public finance and local-development objectives.

Table 2. The readiness gap and its competitiveness effects

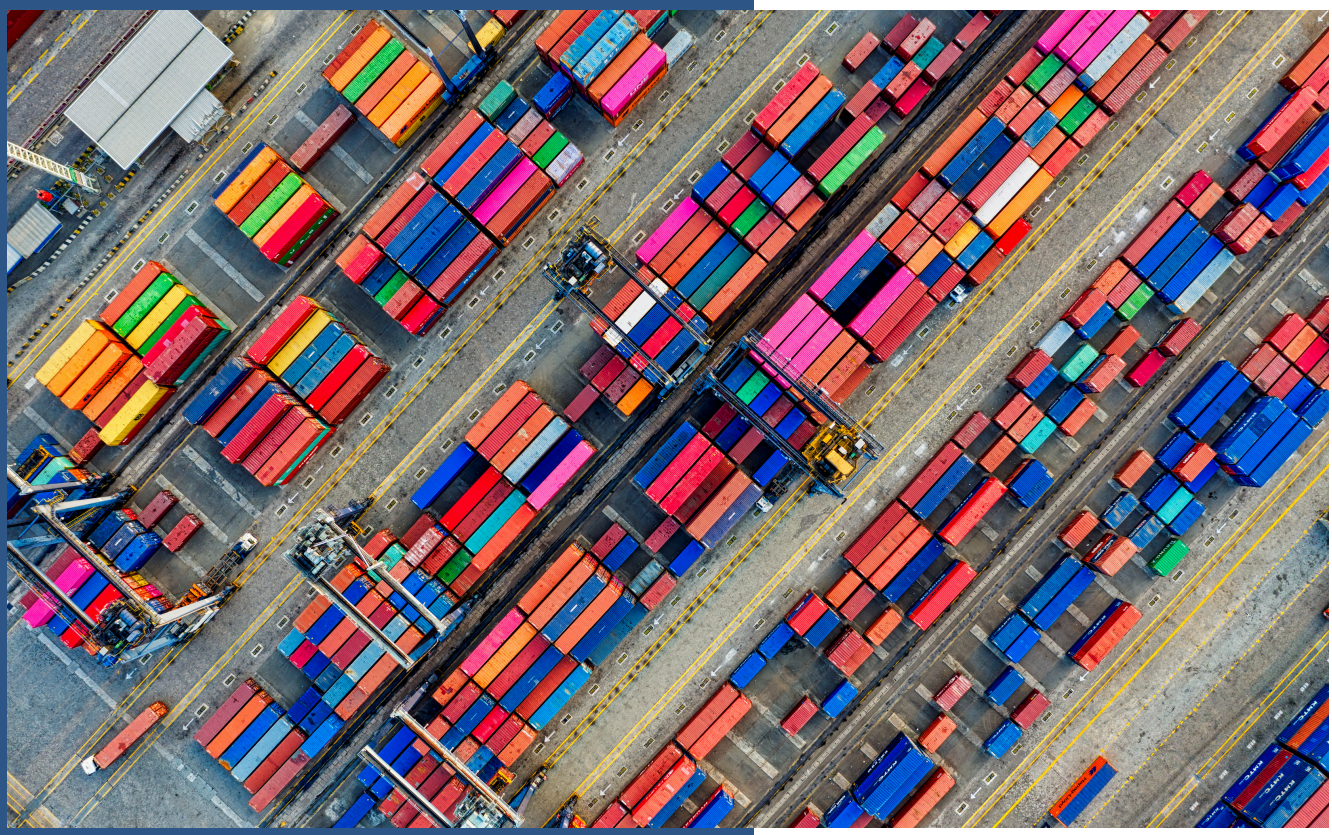
Gate	Evidence required	Decision
Problem definition	Operational and emissions baseline; affected users; policy mandate.	Proceed to options analysis only if the problem is measurable and material.
Technology fit	Vessel/asset profile, lifecycle emissions, safety, infrastructure, maintenance and alternatives.	Select a preferred option, or stop if no option offers defensible value.
Market and demand	User commitments, route frequency, utilisation, fuel or power demand and affordability.	Proceed only where demand is credible or a public-service rationale is explicit.
Project and safeguards	Feasibility, permits, environmental and social safeguards, procurement, skills and emergency response.	Advance to financing after material risks have owners and mitigations.
Finance	Sponsor, capital stack, revenue or savings, currency, guarantees and repayment.	Reach investment decision only when the financing plan is sustainable.
Scale	Verified operational, climate, safety, affordability and maintenance results.	Replicate or expand only after independent evaluation.

Source: Authors' framework

TECHNOLOGY PORTFOLIO

Sustainable Maritime Technologies and Infrastructure Pathways





Technology policy should be built around use cases, not labels. The same technology can be mature in one application and unsuitable in another. The IMO Future Fuels and Technology study concluded that fuel and technology readiness varies materially across options and scenarios, reinforcing the need for staged adoption rather than a single global solution. IRENA similarly treats energy efficiency, renewable electricity, sustainable bioenergy and hydrogen-derived fuels as complementary elements of a longer-term shipping pathway.

Digital operations, data and cybersecurity

Port-call optimisation, berth planning, electronic clearance, cargo visibility, truck appointments and terminal decision-support systems can reduce delays and improve asset use. Their climate contribution arises from changed operations, not from digitalisation itself. A platform that digitises a fragmented or duplicative process may reproduce inefficiency. Projects therefore require process mapping, user governance, data standards, cybersecurity, continuity planning and performance indicators.

Artificial intelligence can support arrival forecasting, equipment maintenance, yard planning and energy management where sufficient data exist. It should not be presented as an automatic solution. Model accuracy, data bias, explainability, cyber exposure, vendor dependence and accountability must be addressed in procurement and governance.

Ship efficiency and retrofit technologies

Operational measures include speed and route optimisation, weather routing, trim optimisation, hull and propeller maintenance, engine tuning and just-in-time arrival. Technical retrofits include propeller and rudder devices, air lubrication, waste-heat recovery, engine power limitation, wind-assisted propulsion and improved coatings. Suitability depends on vessel type, age, route, dry-dock schedule, charter arrangements, fuel price and remaining

economic life. Public policy can support technical assessment and repair capability, but investment decisions generally belong to shipowners and operators.

Electrification and hybrid systems

Battery-electric propulsion is best suited to predictable routes with manageable energy demand and access to charging. Hybrid systems can reduce fuel use and provide operational flexibility for harbour craft, ferries, tugs and vessels with variable load profiles. Port equipment – cranes, tractors, forklifts and service vehicles may offer an earlier electrification opportunity where utilisation is high and grid or charging capacity is available. Battery projects require fire detection, ventilation, emergency response, charging management, spare parts, technician capability and an end-of-life strategy.

Shore power and port energy systems

Shore power allows compatible ships to switch off auxiliary engines at berth, reducing local air pollution, noise and at-berth emissions. Its business case depends on call frequency, time at berth, vessel compatibility, electricity price, grid carbon intensity, connection standards and responsibility for capital cost. Renewable-energy systems and microgrids can improve resilience and lifecycle performance, but claims of zero-emission electricity require credible sourcing and accounting.

Biofuels, methanol, hydrogen and ammonia

Sustainable biofuels can be used in existing or adapted engines and may support near-term reductions, but feedstock competition, indirect land-use effects, traceability, quality and certification are material risks. The direction of IMO policy is to tie any favourable treatment of alternative fuels to recognised certification and demonstrated lifecycle performance, consistent with the 2024 LCA Guidelines (MEPC.391(81)); the specific interim treatment of individual fuels should be confirmed against the latest MEPC outputs before reliance.

Methanol is liquid at ambient conditions and has attracted vessel orders and bunkering trials, but low-GHG performance depends on the production pathway. Fossil methanol offers limited climate value; biomethanol and e-methanol require sustainable carbon and renewable energy. Hydrogen can serve fuel cells in selected applications and is a feedstock for e-methanol and ammonia; its low volumetric energy density and storage requirements constrain direct use. Ammonia contains no carbon at the point of use but introduces toxicity, potential nitrous-oxide emissions and significant safety requirements. This paper therefore uses “zero or near-zero GHG” only when lifecycle evidence supports the description.

Shipbuilding, conversion, maintenance and repair

Africa’s most realistic industrial opportunity may not begin with building large ocean-going zero-emission vessels. It may begin with maintenance, conversion, electrical integration, battery systems, port equipment, small-vessel construction, fuel handling, inspection and data services. Procurement should assess how local firms can participate without compromising safety or quality. Technology-transfer provisions need measurable commitments: training hours, local supplier qualification, documentation, warranty support, software access, spare parts and knowledge retained after the vendor leaves.

Table 4. Technology suitability matrix

Technology pathway	Most suitable early applications	Critical conditions	Primary caution
Operational and digital optimisation	Ports, terminals and regular corridors with measurable delays.	Process governance, interoperable data, user adoption and cybersecurity.	Software does not correct weak institutions by itself.
Ship efficiency and retrofits	Existing vessels with sufficient remaining life and a clear operating profile.	Technical assessment, owner incentives, dry-dock access and performance verification.	Savings vary by ship, route and operational discipline.
Battery-electric and hybrid	Ferries, harbour craft, tugs, inland vessels and port equipment.	Predictable duty cycle, charging, safety, maintenance and battery-lifecycle plan.	Less suitable for energy-intensive long-range operations.
Shore power	Berths with regular compatible vessels and adequate grid capacity.	Utilisation, standards, tariff, grid emissions and cost sharing.	Under-used systems can become stranded assets.
Sustainable biofuels	Existing fleets where certified feedstock and supply exist.	Lifecycle certification, fuel quality, price and feedstock governance.	Food, land-use and traceability risks.
Low-GHG methanol	Selected gateway ports and regular trades with supplier and vessel demand.	Certified production, storage, safety, training and offtake.	Fossil methanol is not a net-zero solution.
Hydrogen	Selected short routes, fuel cells, industrial feedstock and pilots.	Renewable electricity, storage, safety, maintenance and demand.	Energy density, cost and infrastructure requirements.
Ammonia	Potential deep-sea corridors and industrial clusters over the longer term.	Lifecycle production, toxicity controls, standards, emergency response and offtake.	Nitrous-oxide risk; commercial maturity remains developing.

Source: Authors' synthesis based on IMO Future Fuels and Technology, IMO LCA guidance and IRENA shipping analysis.



PUBLIC POLICY AND OPERATIONAL REFORM

Policy Priorities by Actor and Time Horizon

7



Policy should distinguish between obligations, enabling reforms, project preparation and investment decisions. It should also recognise that institutional models differ. A country with an autonomous port authority, a landlord port and private terminals may need a different coordination mechanism from a state-operated port system or an island ferry network. The objective is accountable coordination through existing mandates wherever possible, not the automatic creation of new committees.

Immediate priorities: 0 to 2 years

National governments should map the application of IMO and regional requirements, identify responsible authorities, and integrate maritime decarbonisation into transport, energy, climate, trade, industrial and skills policy. Maritime administrations should strengthen EEXI, CII, SEEMP, DCS and lifecycle-fuel literacy. Port authorities should complete operational and emissions baselines, comply with the maritime single-window requirement, identify cargo-flow bottlenecks and develop energy and safety gap assessments. Finance ministries and development partners should establish or access project-preparation support. Universities and academies should conduct competency mapping and develop modular courses with regulators and industry. Port users, carriers and cargo owners should participate in data and demand assessment. Regional bodies should identify opportunities for common guidance, shared training and corridor coordination.

Medium-term priorities: 3 to 5 years

The medium term should move credible projects from feasibility into implementation. Ports and operators can scale proven digital systems, energy management, low-emission equipment and selected electrification. Governments can update technical codes, occupational-safety arrangements, tariff structures and public-procurement rules. Utilities and ports can implement shore-power or charging projects where demand and grid studies support them. Corridor partnerships can develop offtake and investment structures for selected routes.

Long-term priorities: 6 to 15 years

Longer-term policy should support regional standards, larger fleet renewal, corridor integration, fuel and renewable-energy clusters, ship repair and conversion, local supplier capability and research systems. These measures should remain conditional on

demonstrated comparative advantage, lifecycle performance and fiscal sustainability. Governments should avoid long-term guarantees that socialise technology or demand risk without transparent public value.

Table 5. Actor-specific policy priorities

Actor	0 to 2 years	3 to 5 years	6 to 15 years
AU and regional bodies	Develop common guidance, knowledge exchange and negotiation support.	Coordinate corridor studies, standards and regional training.	Support interoperability, regional infrastructure and industrial cooperation.
National governments	Align policy, mandates, baselines and project preparation.	Adopt enabling regulation, procurement and risk-mitigation mechanisms.	Integrate maritime, energy, industrial and trade strategies.
Maritime administrations	Strengthen compliance, lifecycle-fuel and safety capability.	Approve pilots, inspections and competency systems.	Maintain adaptive standards and international representation.
Port authorities and terminals	Measure operations and emissions; plan digital, energy and safety reforms.	Implement and evaluate selected assets and operational systems.	Scale proven models and support corridor/fuel integration.
Carriers and cargo owners	Share route, call, demand and emissions data; join feasibility work.	Commit vessels, cargo or offtake where projects are viable.	Support long-term corridor and fleet transitions.
Energy companies and utilities	Assess grid, renewable, storage, land and water capacity.	Develop selected charging, shore-power or fuel supply.	Scale integrated energy and maritime clusters.
Finance institutions	Fund preparation and identify risk instruments.	Provide debt, guarantees, equity or leasing to investable projects.	Support portfolio and regional infrastructure finance.
Universities and academies	Map skills, research needs and curricula.	Deliver training, applied research and independent evaluation.	Build regional centres of competence and innovation.
Workers and communities	Participate in needs, safety and affordability assessment.	Co-design transition, training and safeguards.	Share in durable employment and local-development benefits.

Source: Authors' framework

Continental and regional institutional responsibilities

Africa's largest continental and regional institutions can reduce fragmentation by aligning policy, preparing investment, coordinating corridors and strengthening technical capability. The roles below are practical areas for action within existing mandates; they are not statements of formal commitment, and no institution named here has endorsed this paper or agreed to the actions described.

Table 6. Continental and regional institutional action agenda

Institutional actor	Priority contribution	Near-term output
African Union Commission	Align maritime decarbonisation with the 2050 AIM Strategy, Agenda 2063, climate policy and the blue economy agenda.	Continental policy principles and a coordination forum.
AfCFTA Secretariat	Connect the maritime transition to trade facilitation, corridor performance and supply-chain competitiveness.	A maritime logistics and green-trade workstream.
AUDA-NEPAD	Link priority port and corridor projects to continental infrastructure planning and project preparation.	A screened pipeline of regional projects.
African Development Bank and infrastructure platforms	Support preparation finance, concessional capital, guarantees and regional investment dialogue.	Preparation facilities and investable transactions.
Regional economic communities	Coordinate corridor policy, customs interoperability, safety cooperation and common training needs.	Regional action plans for selected corridors.
African port and maritime associations	Share operational data, benchmarks, lessons and common technical needs.	Peer-learning network and voluntary performance framework.
African universities and maritime academies	Develop evidence, curricula, safety capability and applied technology assessment.	Regional research and skills consortium.

Source: Authors' framework based on the established functions of the institutions listed

Governance options

Three governance models are available. A national taskforce can coordinate multiple ministries where mandates are fragmented. A lead-agency model can work where one transport or maritime institution already has convening authority. A port-cluster model can organise delivery around a major port, industrial zone and corridor. Whichever model is used, it needs a published mandate, work programme, data arrangements, budget, decision rights, conflict-management process and annual reporting. Temporary donor project units should not substitute for permanent institutional responsibility.



CAPITAL AND RISK

Financing Architecture for Bankable Green Maritime Investment

8

Green maritime finance is frequently discussed as a shortage of capital. In many cases, the prior shortage is of prepared projects. Investors and lenders need a capable sponsor, a defined asset, users, technical design, permits, procurement, safeguards, cash flow or quantified savings, risk allocation and credible implementation. A port authority may have a strategy without having an investable transaction.

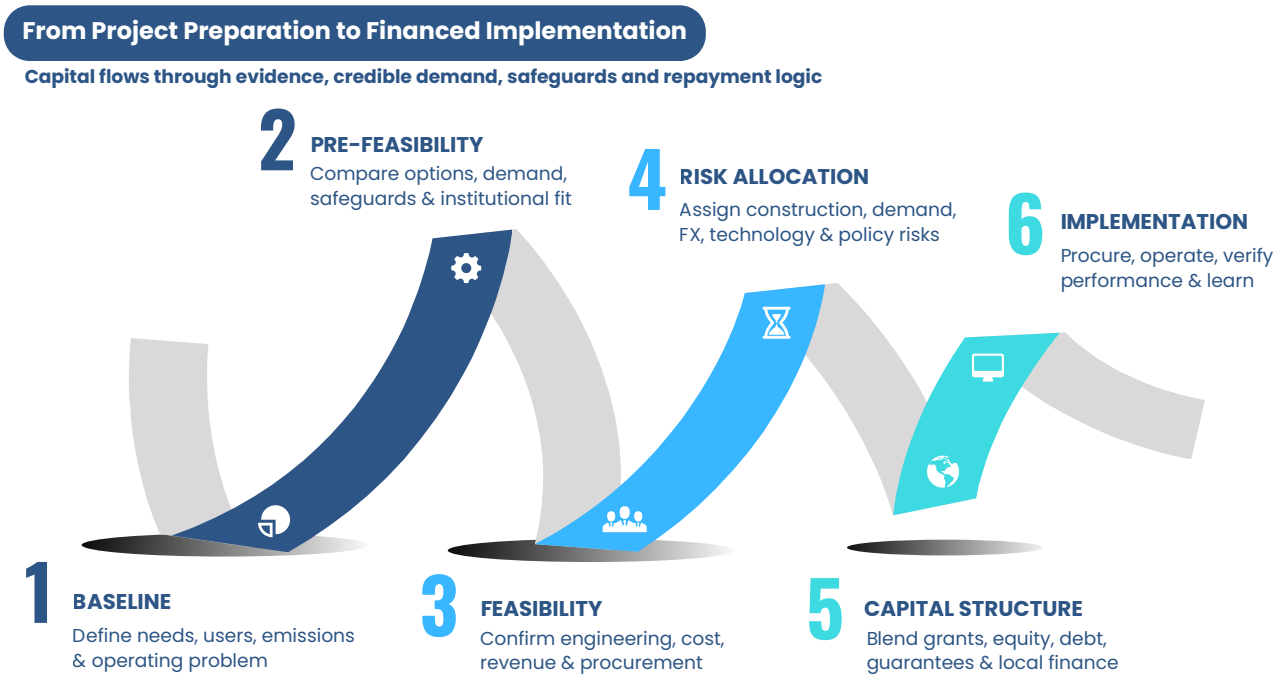


Figure 5. Financing architecture for green maritime projects

Source: Authors' framework

Match instruments to assets

Grants and technical assistance are appropriate for public-good activities such as policy development, inventories, feasibility, standards, training and early demonstration. Concessional debt can support long-lived infrastructure where public benefits exceed direct revenue, and continental instruments such as the African Development Bank's green-investment initiatives are potential sources of preparation support and concessional capital. Commercial debt and operator capital are more suitable when assets generate reliable fees or cost savings. Leasing and vendor finance can reduce upfront cost for equipment. Guarantees and political-risk insurance should target specific risks rather than compensate for an unviable project. A PPP is suitable only where the service, payment mechanism, risk transfer and public value can be clearly defined.

Foreign exchange, affordability and demand

Foreign-exchange risk is particularly important where imported equipment and hard-currency debt are repaid from local-currency revenues. Currency depreciation can make a technically sound project unaffordable. Mitigation may include local-currency lending, indexed tariffs, hedging, guarantees, blended structures or foreign-currency revenue, but each option shifts cost or risk to another party. Public decision-makers should disclose who bears that risk.

Demand risk differs by asset. A digital platform may depend on mandatory user participation and service charges. Shore power depends on compatible vessel calls and electricity prices. Electric ferries depend on route demand and public-service obligations. Alternative fuels require long-term purchase or offtake commitments. Project finance should not assume that supply creates demand.

Climate integrity and safeguards

Climate finance requires measurable additionality and credible emissions accounting. Projects should identify a baseline, project boundary, lifecycle effects, leakage, monitoring method and attribution. Carbon-credit revenue should be treated as uncertain and supplementary unless a recognised methodology, buyer and verification structure exist. Ports and terminals should apply environmental, health and safety good practice, including hazardous materials, emergency response, occupational safety, community exposure and biodiversity.

Table 7. Asset-level financing matrix

Investment	Likely sponsor and repayment logic	Potential instruments	Key risks and mitigations
Inventories, studies and training	Public agency, port or programme budget; no direct revenue.	Grants, technical assistance, public co-finance and preparation facilities.	Weak ownership: link funding to a named institution and a follow-on decision.
MSW and port community systems	Government/port/operator; fees or operational savings may support cost recovery.	Public investment, concessional debt, operator capital or service contract.	Low adoption and cyber risk: mandate, governance, interoperability and security testing.
Port equipment electrification	Terminal or port; fuel and maintenance savings.	Operator equity, green loan, leasing, vendor finance or concessional co-finance.	Technology and residual-value risk: lifecycle analysis, warranty and maintenance plan.
Electric ferry or harbour craft	Public authority, operator or special-purpose entity; fares, availability payments or service contract.	Blended debt/equity, leasing, guarantees and public-service support.	Demand, tariff and battery risk: route evidence, affordability and replacement reserve.
Shore power	Port, utility or concession; connection and electricity charges.	Port/utility capital, concessional debt, grants for enabling works or PPP.	Utilisation and grid risk: vessel commitments, load study, standards and tariff agreement.
Renewable port power or microgrid	Port, utility, terminal or energy-service company; savings and energy sales.	Project finance, green loan, lease or power-purchase agreement.	Grid, curtailment and credit risk: bankable offtake and system integration.
Alternative-fuel infrastructure	Fuel producer/supplier, port and strategic investors; fuel sales and services.	Equity, DFI debt, export credit, guarantees and offtake-backed finance.	Demand, price, certification and safety risk: staged capacity and binding counterparties.
Ship repair and conversion	Shipyard or industrial operator; service revenue.	Commercial/DFI debt, equity, vendor finance and training grants.	Pipeline and skills risk: anchor customers, quality systems and workforce plan.

Source: Authors' framework

A preparation-to-finance sequence

Capital does not attach to ambition; it attaches to a project that has passed a disciplined preparation sequence. Each step below is a gate rather than a formality, and the appropriate financing instrument changes as the project matures. Grants and technical assistance belong at steps 1 to 4, where there is no revenue to repay debt; concessional and commercial finance, leasing and guarantees attach only once demand and cost recovery are credible at steps 5 to 7. Skipping a step does not accelerate a project; it usually delays financial close, because the omitted evidence is demanded later under less favourable terms.

Table 8. The preparation-to-finance sequence

Step	What must be established	Typical financing at this step
1. Problem and baseline	A measurable operational or emissions problem, a named sponsor and a policy mandate.	Public budget, grant or preparation facility.
2. Options and technology fit	Lifecycle, safety and infrastructure screening of candidate options against alternatives.	Grant or technical assistance.
3. Demand and revenue logic	Binding or credible users, route/utilisation evidence, or an explicit public-service rationale.	Grant; early concessional interest.
4. Feasibility and safeguards	Technical design, environmental and social assessment, permits and a safety case.	Preparation facility; project-development capital.
5. Capital structure	Instrument matched to cash flow; FX, affordability and demand risk allocated and disclosed.	Concessional debt, guarantees, blended structures.
6. Investment decision and close	A sustainable financing plan and an accountable owner able to carry residual risk.	Commercial and DFI debt, equity, leasing.
7. Implementation and hand-over	Contracts embedding data, training, maintenance, cybersecurity, warranty and local-supplier obligations.	Drawdown against milestones.
8. Evaluation before scaling	Independent post-commissioning evaluation of operational, climate, safety and affordability results.	Follow-on finance only if verified.

Source: Authors' framework



INSTITUTIONAL COLLABORATION

Partnership Architecture for Implementation

9

No single institution controls the maritime transition. IMO rules apply to ships and administrations; ports control infrastructure and services; utilities control power; fuel suppliers manage production and distribution; carriers and cargo owners shape demand; finance institutions assess risk; training bodies develop competence; workers and communities experience the transition. Partnerships must therefore be designed around a deliverable, not a ceremonial list of organizations.



Figure 6. Partnership ecosystem for implementation
Source: Authors' framework. Named institutions in the text are potential categories, not confirmed partners

The role of Innovate Maritime Africa

Innovate Maritime Africa can contribute in five areas: evidence synthesis; convening across sectors; readiness and screening tools; project-concept development; and policy communication. It can request access to public data, technical peer review, co-design, preparation support and institutional participation. It should not represent itself as the approving authority, financier, verifier or owner of infrastructure unless a formal mandate establishes that role.

Table 9. Partnership architecture

Partner category	Value required from partners	Value Innovate Maritime Africa can offer	Practical collaboration mechanism
Policy and regulatory	Mandate, policy alignment, legal interpretation and access to decision processes.	Research synthesis, consultation design and implementation frameworks.	Technical working group, policy dialogue or formal advisory arrangement.
AU and regional coordination	Continental alignment, cross-border coordination and regional legitimacy.	Comparative African evidence, corridor concepts and knowledge products.	Joint research, regional forum or guidance development.

Ports, carriers, terminals and cargo owners	Operational data, sites, demand, vessels, cargo and implementation.	Use-case design, stakeholder coordination, monitoring and dissemination.	Data agreement, pilot consortium or corridor feasibility partnership.
Energy and technology	Engineering, utilities, products, safety data, maintenance and training.	Independent problem definition, local context and partner mobilization.	Technology-neutral feasibility, demonstration and vendor-qualification process.
Finance and project preparation	Preparation funding, debt, equity, guarantees and transaction advice.	Pipeline origination, policy engagement and local stakeholder mapping.	Preparation facility, investment roundtable or project-screening partnership.
Knowledge and education	Peer review, research, curricula, laboratories and evaluation.	African research agenda, cases, dissemination and practitioner access.	Research consortium, fellowship, training or independent evaluation.
Safety, class and standards	Technical rules, risk assessment, verification and competency guidance.	Policy translation, local training needs and implementation platforms.	Safety working group, gap assessment and train-the-trainer programme.
Workers, communities, women and youth	Operational experience, social legitimacy, needs and safeguards.	Inclusive consultation, evidence visibility and pathway design.	Advisory panel, skills initiative and social-impact monitoring.
Communication and convening	Reach, public engagement and sector networks.	Evidence-led content and expert access.	Launch, webinar series, professional briefing and annual progress dialogue.

Source: Authors' framework

Accountability in partnership

Partnership agreements should define scope, outputs, data ownership, intellectual property, funding, procurement, conflicts of interest, public communication, safeguards, dispute resolution and exit. Technology providers should not control independent evaluation of their own product. Financiers should not be named as partners before approval. Public institutions should distinguish technical participation from institutional endorsement. Annual progress reporting should identify both delivery and non-delivery.



TRANSFERABLE LESSONS

African and International Case Studies

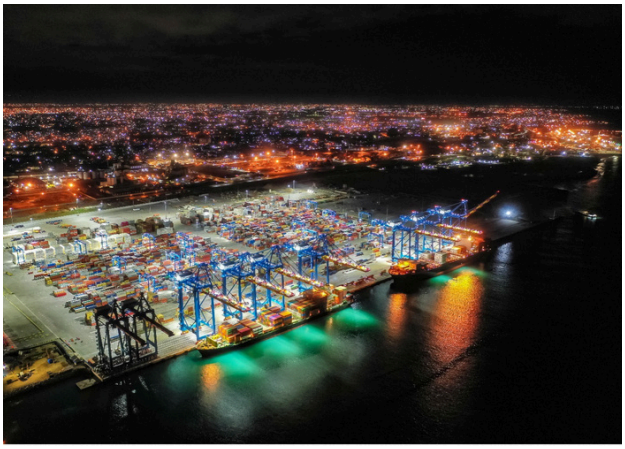
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Case studies are useful when they expose the institutional mechanism behind a result, and misleading when a large, well-financed port is presented as a template without regard to differences in grid, demand, regulation and fiscal capacity. The cases below are grouped into two sets. The first are African examples, presented as live processes rather than completed impact evaluations, and, where drawn from institutional self-reports, identified as such. The second are transferable international lessons, included for their institutional mechanisms rather than their scale, which differs markedly from most African settings.

African cases

Case 1: Port of Tema, Ghana (port-call optimization)

In June 2026, IMO's GreenVoyage2050 program reported work with the Port of Tema to develop a concrete implementation plan for port-call optimisation and just-in-time shipping. The initiative brings together the terminal, authorities, shipping lines and service providers to align operational, technical and governance arrangements, while supporting Ghana's national maritime decarbonisation planning. The lesson is that just-in-time arrival is not a software installation. It requires shared timestamps, reliable berth and nautical-service information, cooperation across public and private actors, and changes to operating practices. Tema is a current implementation process rather than a completed impact evaluation; emissions and efficiency results should be reported only after verified measurement.



Case 2: Port of Mombasa, Kenya (green-port operations)

Kenya Ports Authority's 2025 institutional reporting describes implementation under a Green Port Policy 2024 to 2028, including solar power, hybrid rubber-tyred gantry cranes, electric equipment and shore-power planning for port marine craft. The case demonstrates how a port can combine energy, equipment and policy measures rather than waiting for a future fuel hub. The transfer lesson is to begin with the port's own controllable assets and to connect procurement with maintenance, operator training and measurement. Because the published evidence is an institutional self-report, claims about fuel or emissions reductions require independent verification and consistent baselines before being generalised.



Case 3: South Africa to Europe iron-ore corridor (cargo-led feasibility)

A 2025 feasibility assessment led by the Global Maritime Forum examined a South Africa to Europe iron-ore green shipping corridor, including the potential deployment of green-ammonia vessels from 2029 and scaling toward 2035 under specified assumptions. It identified Saldanha Bay's possible future role and the need for cargo certainty, fuel supply, vessels, port infrastructure, safety, finance and policy coordination.

The case is relevant because bulk cargo and identifiable cargo owners can support route-based planning. Its dates are feasibility findings, not final investment commitments. Other African routes should not copy the fuel choice without replicating the demand, vessel, energy and risk analysis.



Case 4: Africa's connectivity gains (Investment translated into competitiveness)

Africa was the fastest-improving region on UNCTAD's Liner Shipping Connectivity Index between mid-2024 and mid-2025. The clearest national example is Cameroon, whose connectivity rose 54%, driven by the deep-water port of Kribi and a roughly threefold increase in the maximum vessel size it can accommodate; Mauritania and Namibia each improved by 43%. Part of the shift reflects the rerouting of services away from the Red Sea, which is not a permanent structural gain.

The lesson has two sides. Targeted infrastructure that unlocks larger vessels and denser services can move a country's competitiveness quickly, which is exactly the kind of outcome a readiness-led pipeline is designed to capture. But connectivity driven by temporary rerouting must be consolidated through reliable operations, data and onward logistics, or it will recede when trade patterns normalise. Connectivity is a platform for the transition agenda, not a substitute for it.

Transferable international lessons

Case 5: Tanger Med, Morocco (Renewable electricity and integrated port-industrial strategy)

Tanger Med's 2024 sustainability reporting states that the port complex and logistics zone were supplied with 100% green electricity and describes wider work on energy efficiency, mobility and industrial sustainability. The case illustrates the advantage of integrating port, logistics and industrial-zone planning rather than treating the port boundary as the whole system. The lesson is not that renewable electricity can be declared through procurement alone. Replication requires clarity on the electricity instrument, additionality, grid conditions, load, price and how reductions are attributed. Large integrated complexes also have resources and scale that smaller ports may not possess.



Case 6: Norway (Electric ferries through procurement and public support)

Norway's electric-ferry transition was accelerated by public procurement, innovation contracts, infrastructure support and a predictable public-service market. The all-electric MF Ampere entered service in 2015, and public authorities subsequently used low- and zero-emission requirements, funding and tender design to expand deployment across a large share of the national ferry fleet. The transferable lesson is demand creation: technology scaled because public buyers specified outcomes and supported infrastructure. African island and inland-water systems can adapt this approach where routes are predictable, but

must account for grid reliability, fare affordability, vessel size, spare parts and public fiscal capacity.



Case 7: Singapore and Rotterdam (Standards before scale)
Singapore developed methanol bunkering through trials, technical standards, licensing criteria, lifecycle-intensity requirements, chain-of-custody expectations and emergency preparedness, with licences awarded for 2026 to 2030 creating a controlled framework for suppliers rather than assuming that a fuel market will organise itself. Rotterdam commissioned cruise shore power in March 2025 after a multi-year project involving the port, municipality, grid operator and engineering partners. Both cases demonstrate that infrastructure follows standards, users and institutional coordination. Their scale, regulation and financial resources differ from many African ports. The transferable components are staged trials, technical reference documents, licensing, user commitments, grid planning and clear responsibility for operation and safety.





PEOPLE AND CAPABILITY

Just Transition, Skills, Safety and Local Value Creation

11

The transition will be implemented by people: seafarers, port workers, technicians, regulators, inspectors, emergency responders, data specialists, trainers, researchers, managers and small operators. Technology without competence creates safety and maintenance risk; climate policy without social legitimacy can increase inequality or fail politically.

Workforce capability

The maritime workforce is diverse and globally distributed, with long-standing differences in occupation, gender, employment status and working conditions. The ILO has emphasised the importance of understanding these workforce characteristics when designing a just transition. UNCTAD reports that women now hold close to 40% of port managerial positions but remain under-represented in operational roles, precisely where automation and new technologies will reshape work. A skills strategy should therefore begin with occupational mapping rather than a generic training target.

Priority competencies include emissions accounting; energy management; electrical and battery systems; fuel handling; occupational safety; emergency response; digital and cyber operations; alternative-fuel inspection; lifecycle assessment; maintenance; project management; procurement; and environmental and social safeguards. Training should be linked to recognised competency standards, practical facilities and employer demand. Short courses can address immediate gaps, while diploma and degree programmes develop long-term capability.



Safety as a precondition

New fuels and high-voltage systems change hazard profiles. Safety should be integrated from concept design through operation, not added after procurement. A pilot should have hazard identification, class and regulatory review, standard operating procedures, emergency plans, drills, incident reporting, competent staff, maintenance arrangements and coordination with local fire and health services. Port communities also need information where hazardous storage or bunkering changes local risk.

Just-transition principles

A just transition requires participation, decent work, social dialogue, skills and protection for those who bear adjustment costs. In maritime systems, this includes seafarers whose competencies change, workers affected by automation or fuel transition, small ferry and fishing operators facing equipment cost, and users exposed to higher fares. It also requires deliberate pathways for women and young people into technical, regulatory and enterprise roles rather than limiting inclusion to awareness events.

Local value creation
Local-content claims should be tied to what can be delivered safely and competitively. Potential areas include electrical installation, charging, renewable-energy systems, software integration, equipment maintenance, small-vessel construction, retrofits, inspection support, training, data services and environmental monitoring. Procurement can require supplier-development plans, local technician training, documentation transfer, spare-parts availability and performance reporting. Targets should reflect market capability and should not undermine safety or create hidden cost.

Table 10. Human-capability and just-transition framework

Capability domain	Priority competencies	Who trains and certifies	Just-transition safeguard
Emissions and lifecycle	Inventory boundaries, well-to-wake accounting, MRV/DCS reporting.	Maritime academies, universities and regulators.	Open, recognised competency standards; access for smaller operators.
Energy and electrical	High-voltage systems, shore power, charging management, battery safety.	Technical/vocational institutes, utilities and class societies.	Certified progression routes; occupational safety guarantees.
Alternative fuels	Methanol, ammonia and hydrogen handling, bunkering, emergency response.	Class societies, fire and health services, and operators.	Community information and consent where local risk changes.
Digital and cyber	MSW/PCS operation, data governance, cybersecurity hygiene.	Universities, platform operators and administrations.	Protection and re-skilling where automation displaces roles.
Maintenance and repair	Preventive maintenance, spare-parts management, retrofit and conversion skills.	Shipyards, vendors and TVET providers.	Local technician development retained after vendor exit.
Regulation and inspection	Alternative-fuel inspection, safety-case review, standards application.	Maritime administrations and regional bodies.	Independent capability, not dependence on vendors.
Inclusion pathways	Technical, regulatory and enterprise roles for women and youth.	Programme sponsors, academies and employers.	Measured participation and advancement, not awareness events.

Source: Authors' framework informed by ILO just-transition and maritime-workforce guidance and UNCTAD workforce data.

DELIVERY

Implementation Roadmap, Flagship Initiatives and Decision Gates



12

Implementation should avoid two common failures: attempting all actions at once, and remaining indefinitely in policy dialogue. The pathway below links phases to decision gates. Progress is not automatic. A project advances only when evidence, ownership, safety, demand, finance and implementation capacity are sufficient.

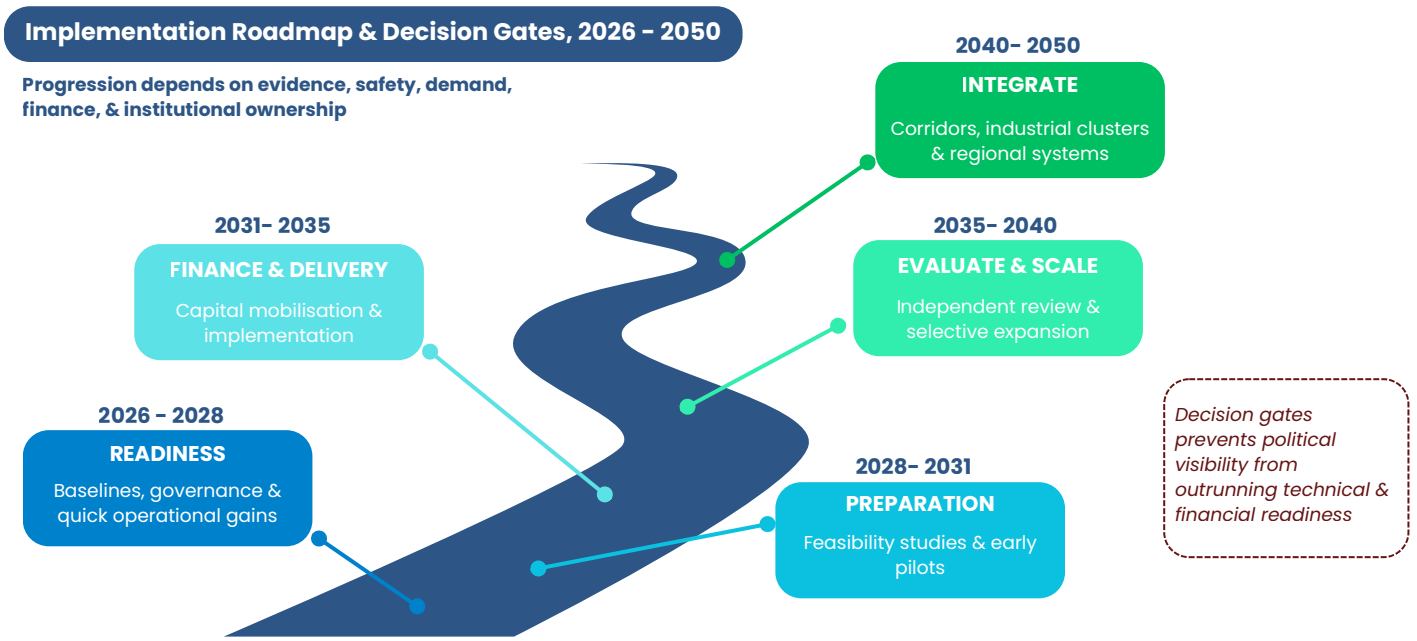


Figure 7. Implementation roadmap and decision gates, 2026 to 2050

Source: Authors' framework

Phase 1: Readiness, evidence and quick operational gains, 2026 to 2028

The first phase establishes institutional ownership, regulatory mapping, emissions and operational baselines, digital and energy audits, safety and skills assessments, and a prioritised project pipeline. Quick gains should focus on maintenance, arrival coordination, pre-clearance, cargo flow, energy management and existing-system interoperability. The decision gate is an approved baseline and a small portfolio of projects with named sponsors.

Phase 2: Project preparation and early pilots, 2028 to 2031

The second phase completes feasibility, safeguards, technical design, procurement strategy, demand analysis and financing options. Pilots should test a defined use case and include a counterfactual or baseline. The decision gate is an investable project with approved safety and environmental arrangements, credible users and a financing plan.

Phase 3: Finance and implementation, 2031 to 2035

The third phase mobilises capital and implements selected digital, energy, equipment, vessel or corridor assets. Implementation contracts should include data, training, maintenance, cybersecurity, warranties, and local-supplier and performance requirements. The decision gate is verified commissioning and an operating period sufficient to assess reliability, cost, safety and emissions.

Phase 4: Evaluation and selective scaling, 2035 to 2040

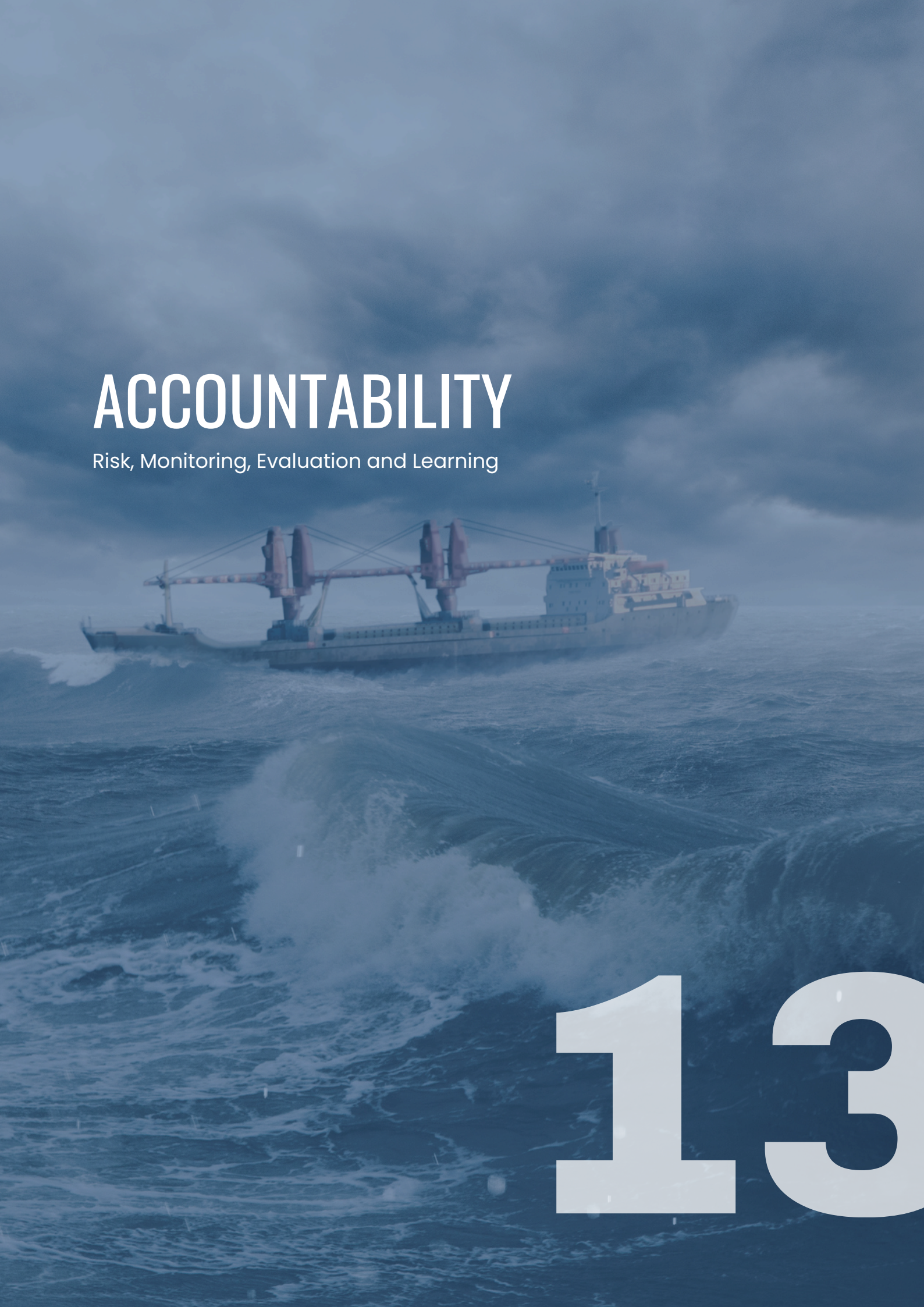
Independent evaluation should determine whether the intervention met operational, climate, financial, affordability and social objectives. Scaling should be selective. A successful port-equipment project may be replicated across terminals; a ferry model may be adapted to other routes; a failed fuel or shore-power project should generate documented lessons rather than be protected from scrutiny.

Phase 5: Corridor and industrial integration, 2040 to 2050
The final phase integrates proven assets into corridors, fuel systems, industrial clusters and regional standards. By this stage, long-term vessel and fuel demand, renewable power, storage, certification, finance and skills should be coordinated at scale. The exact portfolio will depend on technology and regulation that remain uncertain in 2026, which is why the earlier phases privilege reversible, evidence-generating steps.

Table 11. Proposed flagship initiatives

Initiative	Purpose and output	Institutional role of Innovate Maritime Africa	Feasibility condition
African Port Decarbonisation Readiness Assessment	A standard diagnostic covering operations, emissions, digital, energy, safety, skills and finance; piloted with selected ports.	Method development, partner coordination, analysis and publication.	Port participation, data agreement, independent technical review and funding.
Green Maritime Project Preparation and Partnership Roundtable	Screen a limited pipeline and match credible projects with technical and financing partners.	Convening, screening, documentation and follow-up tracking.	Named project sponsors, preparation support and no implication of funding before approval.
African Green Shipping Knowledge and Evidence Platform	Curate regulation, African cases, tools, data notes and policy briefs.	Knowledge management, research partnerships and public communication.	Source verification, update protocol and a sustainable operating model.
Green Maritime Skills and Safety Programme	Develop modular training and train-the-trainer partnerships for priority occupations.	Needs assessment, curriculum coordination and outreach.	Accredited training partners, regulators and employer demand.
Selected Corridor or Vessel-Segment Feasibility Programme	Prepare one or two evidence-based use cases, such as a ferry, harbour craft or cargo corridor.	Research, convening and project-concept development.	Cargo/route data, project owner, safety analysis and preparation funding.

Source: Authors' proposals.



ACCOUNTABILITY

Risk, Monitoring, Evaluation and Learning

13

The credibility of a transition strategy depends on its treatment of failure. Risks should be assigned to institutions able to manage them, monitored through early-warning indicators, and disclosed where they remain material. Monitoring should support management and learning, not only donor reporting.

Risk architecture

Table 12. Strategic risk register

Risk	Impact	Owner and early warning	Mitigation and residual risk
Regulatory uncertainty	High / medium	Government, regulator and project sponsor; changes in IMO or regional texts.	Modular designs and scenario analysis. Residual timing and compliance risk remains.
Weak coordination	High	Lead ministry or port; delayed decisions and duplicated projects.	Mandate, decision rights, budget and escalation process. Political-economy risk remains.
Data and cyber weakness	High	Port and public authorities; data gaps, breaches and system downtime.	Data governance, security testing, redundancy and independent audit.
Technology obsolescence or lock-in	Medium	Sponsor and financier; falling utilisation or incompatible standards.	Technology-neutral screening, modularity, warranties and staged investment.
Demand and utilisation	High	Sponsor, users and financiers; weak commitments or low asset use.	Binding users, conservative forecast, phased capacity and public-service justification.
Safety incident	very high	Regulator, operator and emergency services; near misses or non-compliance.	Safety case, competent staff, drills, inspection and incident learning.
Foreign exchange and affordability	High	Finance ministry, sponsor and lender; currency or tariff stress.	Local currency, risk sharing, hedging and affordability safeguards.
Maintenance and skills failure	High	Operator and training partners; downtime and reliance on foreign technicians.	Lifecycle procurement, spare parts, training, service contracts and local capability.

Greenwashing and weak LCA	Medium	Publisher, project sponsor and verifier; unsupported claims or certification gaps.	Transparent boundaries, recognised methods and independent verification.
Social exclusion and opposition	Medium	Government, sponsor and local authorities; grievances or fare pressure.	Consultation, social dialogue, benefit sharing, grievance process and affordability analysis.
Donor dependency	Medium	Program owner; activity stops after grant period.	National co-ownership, operating model, revenue or budget and capacity transfer.
Geopolitical and supply disruption	Medium	Sponsor and procurement authority; equipment, fuel or parts delays.	Supplier diversification, inventory, adaptable contracts and contingency planning.

Source: Authors' framework

Monitoring and evaluation

Indicators should be defined before implementation. Each needs a baseline, unit, source, collection method, frequency, owner, verification and attribution note. A reduction in port waiting may be associated with several reforms; a project should not claim the entire change without evidence. Financial mobilisation should distinguish commitments, approvals, disbursements and private capital demonstrably mobilised.

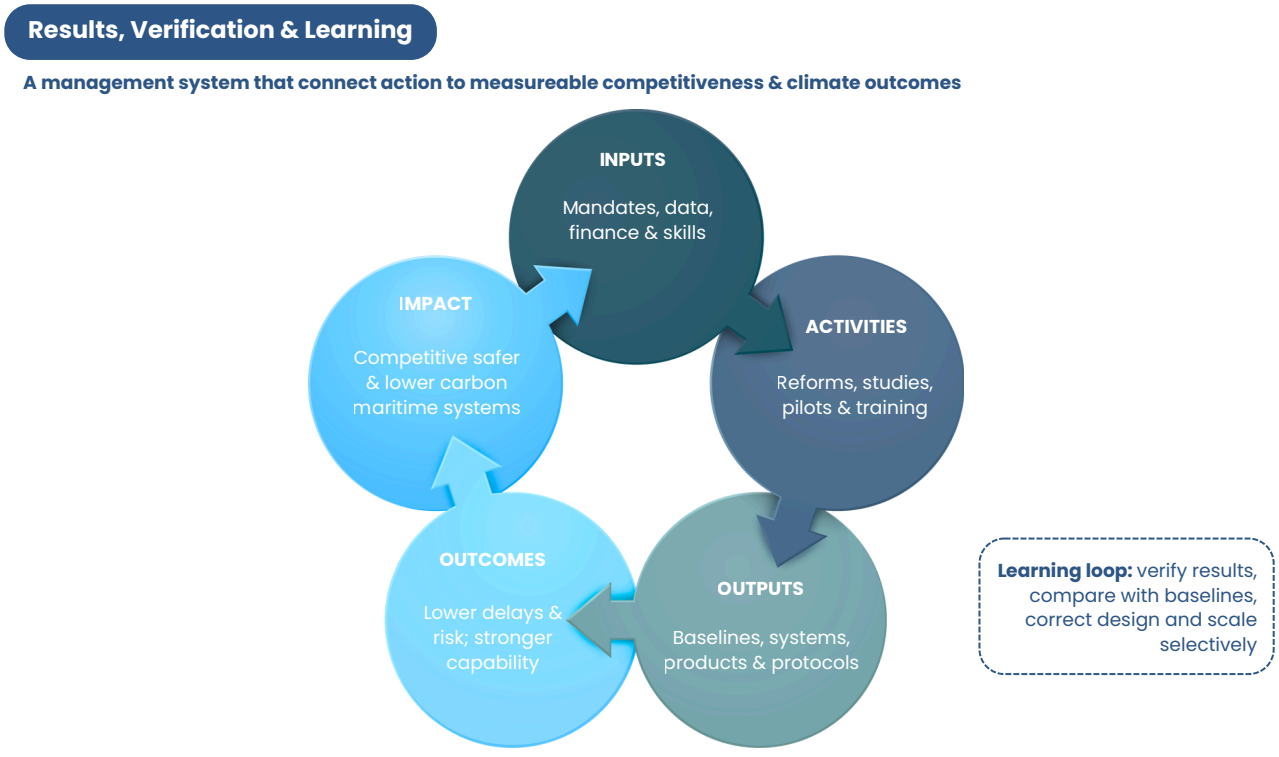


Figure 8. Results and learning framework

Source: Authors' framework

Table 13. Core monitoring framework

Result area	Indicator and unit	Frequency and owner	Verification and attribution
Operations	Anchorage waiting, turnaround, berth productivity, cargo dwell and truck turn time.	Monthly/quarterly; port, terminal and customs.	System data, sampling and independent audit; control for cargo mix and disruption.
Digital	Share of electronic transactions, duplicate submissions, system availability and cyber incidents.	Monthly; public authority and platform operator.	Transaction logs, user survey and security audit.
Energy and emissions	Energy by source, emissions by source, intensity per cargo or service unit.	Quarterly/annual; operator and inventory owner.	Metering, fuel records, defined boundary and recognised factors.
Projects and finance	Projects passing each decision gate; finance approved, committed and disbursed.	Quarterly; sponsor and finance institution.	Document review; distinguish preparation from financial close.
Safety and skills	People trained and certified, drills, incidents, maintenance competency and corrective actions.	Quarterly; regulator, operator and training body.	Certification records, observation and incident audit.
Inclusion and local value	Participation by occupation and level, local suppliers, affordability and grievances.	Semi-annual/annual; sponsor and social partners.	Disaggregated records, worker/user survey and grievance review.
Partnership	Agreements with deliverables, data shared, outputs completed and follow-up actions.	Quarterly; partnership secretariat.	Published tracker; do not count ceremonial MoUs as delivery.

Source: Authors' framework

Learning and correction

Annual reviews should identify which assumptions were wrong, which measures generated value and which projects should stop. A public progress summary can strengthen trust without disclosing commercially sensitive information. The white paper itself should be reviewed periodically as regulation, technology costs, safety standards and African project evidence change.



CONCLUSION

Strategic Outcomes and Call to Action

14

The transition from compliance to competitiveness is not achieved by changing vocabulary. It requires measurable performance, credible institutions and investment decisions that reflect African realities. The near-term opportunity is to reduce avoidable logistics and energy waste, strengthen data and safety, prepare projects and build human capability. The long-term opportunity is selective: some ports and corridors may become fuel, energy, repair, training or data hubs; others will derive greater value from efficient operations, domestic vessel transition and reliable trade facilitation. Africa's negotiating and policy position is stronger when it is supported by its own evidence. Port inventories, route studies, workforce data, energy analysis and project results can inform national policy, regional coordination and IMO deliberations. They also help distinguish legitimate transition needs from technology marketing. The continent should pursue international cooperation while retaining the ability to evaluate lifecycle performance, public value and local-development outcomes.

Each actor has a defined task. Governments should establish policy coherence and project preparation. Ports should measure, reform operations and develop asset-level transition plans. Carriers, cargo owners and energy companies should provide the demand and operational commitments without which corridors and fuel systems cannot be financed. Development-finance institutions should support preparation and risk mitigation while maintaining project discipline. Universities, academies and research institutions should become core delivery partners. Workers, communities, women and young people should participate in design and share in capability and opportunity.

Innovate Maritime Africa will use this white paper as the foundation for a practical programme of readiness assessment, knowledge, skills, project preparation and partnership. Its credibility will depend on disciplined evidence, transparent roles and follow-through. The immediate test is not the number of initiatives announced. It is whether a limited portfolio of African-led interventions moves from baseline to feasibility, from feasibility to finance, and from implementation to independently verified performance.



Decision rule: a six-question readiness test

A green maritime investment should not progress to procurement until six questions have credible answers. Who owns and operates it? Who will use it? What lifecycle emissions and operational benefit will it deliver? What safety and skills system is required? How will capital and operating costs be paid? Which institution is accountable for performance?

SUPPORTING FRAMEWORKS

Annex A. Technical Annexes

The annexes provide adaptable tools. They are not substitutes for engineering, financial, legal, environmental, social or safety due diligence.

Annex A1. Technology screening template

Criterion	Questions for assessment
Use case	Which vessel, berth, equipment or process is being addressed? What duty cycle and operating problem exist?
Maturity	Is the option commercially mature, early commercial, pilot or demonstration in the relevant application?
Lifecycle emissions	What are well-to-wake emissions, electricity source, methane/nitrous-oxide effects and certification needs?
Infrastructure	What grid, charging, storage, bunkering, land, water, digital or maintenance infrastructure is required?
Safety	Which hazards, standards, class rules, emergency services, training and inspection arrangements apply?
Demand	Who will use the asset, at what frequency and under what contractual commitment?
Economics	What capital, operating, fuel/energy, replacement and decommissioning costs arise?
Finance	Who is the sponsor, borrower, payer and risk owner? Which instrument fits the cash flow?
Local value	Which skills, suppliers, maintenance and knowledge can be retained locally?
Scalability	What performance threshold justifies expansion, and what would make the asset stranded?

Annex A2. Partnership due-diligence questions

1. Is the proposed partner's mandate relevant to the deliverable?
2. Has the institution authorised its name, logo and representation?
3. What resources, data, expertise or decisions will each party contribute?
4. Who owns intellectual property and project data?
5. How are conflicts of interest and technology neutrality protected?
6. What are the performance milestones, funding conditions and reporting obligations?
7. How will community, workforce, safety and environmental interests be represented?
8. What happens if the partner does not deliver or exits?

Annex A3. Selected indicator definitions and attribution cautions

Indicator	Definition and unit	Attribution caution
Anchorage waiting time	Mean or median time from arrival at port limits/anchorage to berth, by vessel class.	Weather, congestion, tides and schedule disruption may affect results.

Vessel turnaround	Time from all-fast to last-line, disaggregated by vessel and cargo type.	A lower value is not automatically better if safety or service quality falls.
Cargo dwell	Time cargo remains in port or terminal after discharge/arrival, by category.	Customs, cargo owner, terminal and inland transport all influence the measure.
Energy intensity	Electricity and fuel per TEU, tonne, passenger or operating hour.	Cargo mix and equipment utilisation must be normalised.
Emissions intensity	CO_2e per defined service unit using a declared boundary and emission factors.	Avoid mixing authority, tenant, vessel and corridor emissions without disclosure.
Finance mobilised	Capital contractually committed or disbursed to a project.	Do not count announcements or capital not attributable to the intervention.
Local supplier participation	Value and number of qualified local contracts, disaggregated by service type.	Value alone does not show technology transfer or quality.

Source: Authors' framework.

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